



Developing MACS

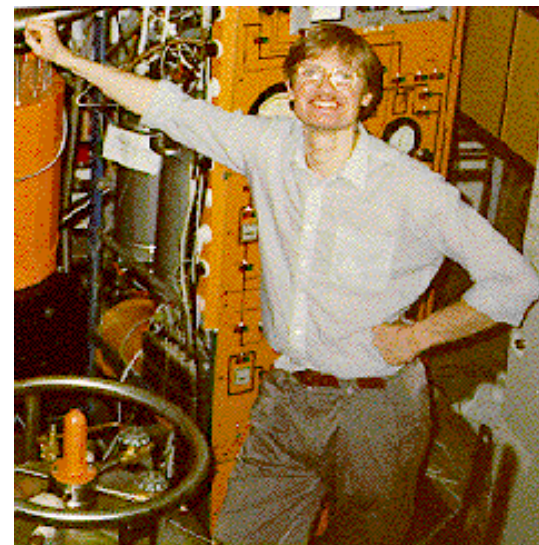
A Third Generation Cold Neutron Spectrometer



What is MACS?

MACS is a Multi Axis Crystal Spectrometer that is under development at the NIST Center for Neutron Research. This third generation cold neutron spectrometer will provide ultra high sensitivity access to dynamic correlations in condensed matter on length scales from 0.1 nm to 50 nm and energy scales from 0.05 meV to 20 meV. The project is funded jointly by the NIST Center for Neutron Research, the National Science Foundation, and the Johns Hopkins University and will be complete in the fall of 2006.

This talk will discuss the state of the design as a snapshot of the overall instrument development process.



Professor Collin Broholm
Johns Hopkins University



Scientific Program and Requirements

- What type of Spectrometer is MACS?
- Which experiments is it good for?
- Specifications to MACS-imize science output



Goals in Neutron Spectroscopy

- A central tool in condensed matter physics
 - Unique information about dynamic correlations
 - Model independent access to interaction strength
 - Access microscopic structure of dynamic systems
- Limited scope on current instruments
 - Need cm³ sized crystals
 - Need weeks of beam time
 - Need to be neutron scattering expert
- Increased sensitivity will broaden impact
 - Smaller samples earlier in new materials cycle
 - Impact in a wider range of science
 - Parametric studies
 - Comprehensive surveys for tests of theory



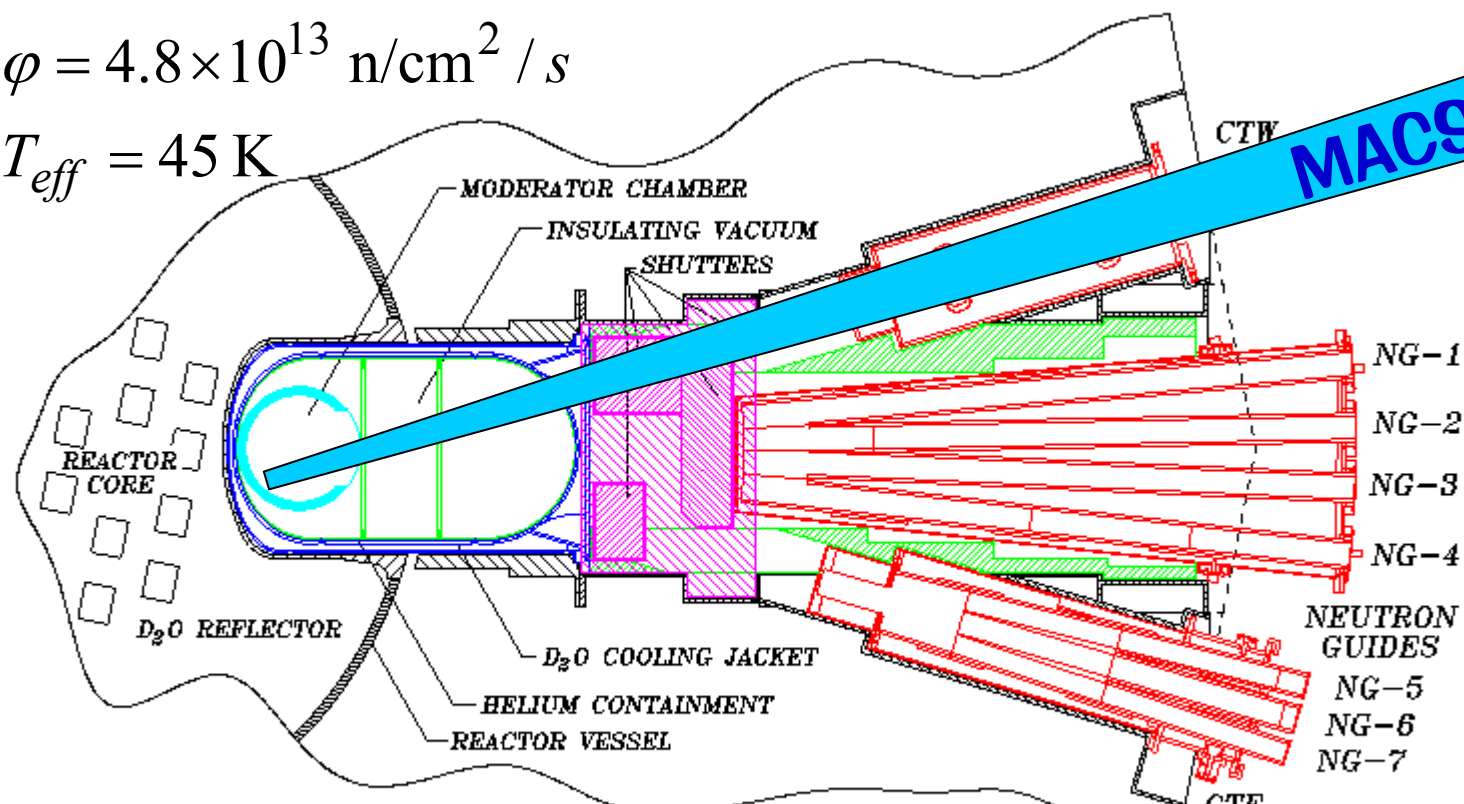
Overall Requirements for MACS

- Maximize sensitivity
 - Maximize flux on sample $\delta E \approx 0.2$ meV, $\delta Q \approx 0.1 \text{ \AA}^{-1}$
 - Maximize detection solid angle at fixed E_f
 - Minimize background
- Optimize performance for users
 - Robust and reliable soft- and hard-ware
 - Standardized dynamic “finger prints” of sample
 - Versatility cannot compromise basic mode
 - Streamline experimental process
- Start Commissioning in 3 years from now

Increase brightness at fixed neutron production

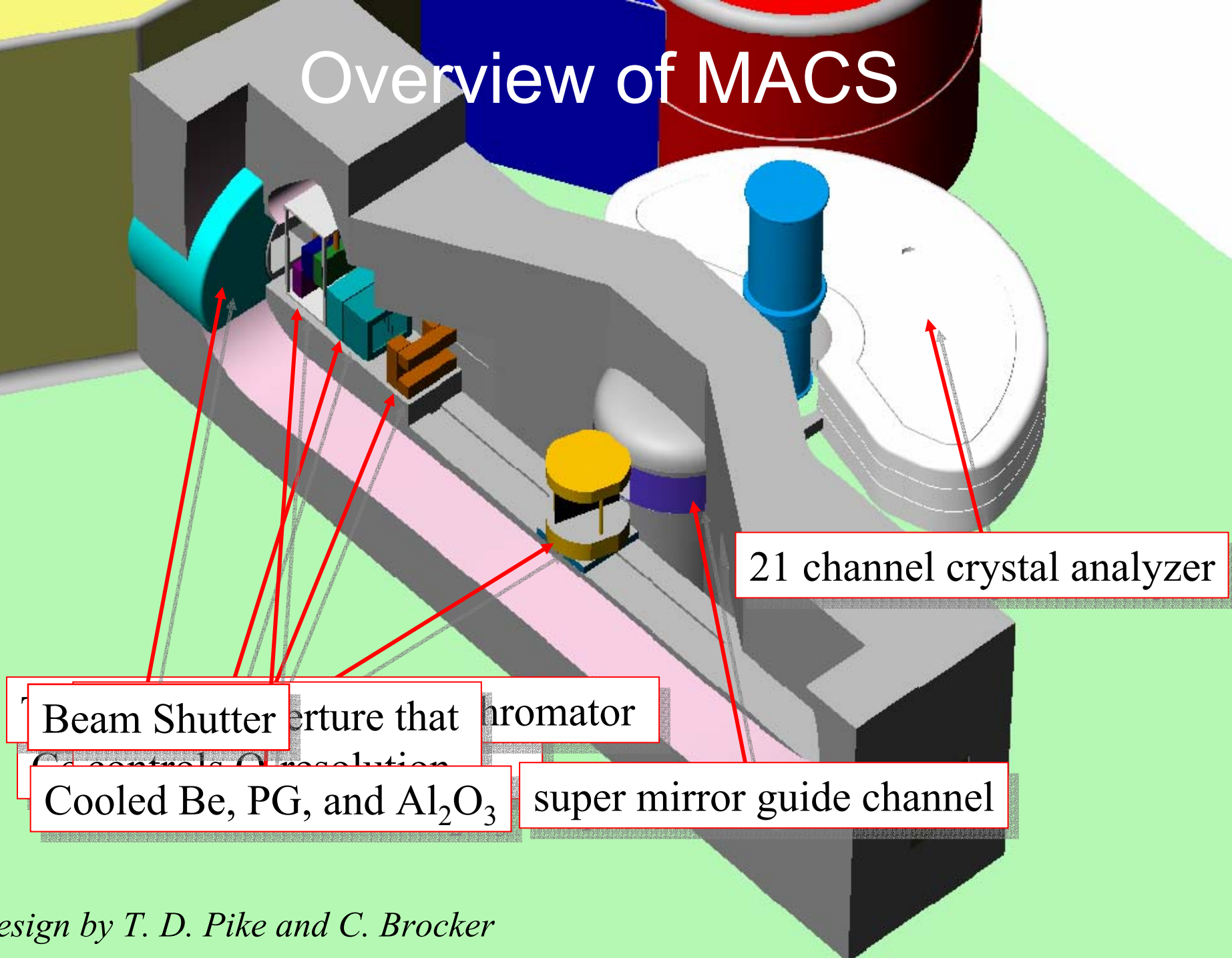
$$\phi = 4.8 \times 10^{13} \text{ n/cm}^2 / \text{s}$$

$$T_{\text{eff}} = 45 \text{ K}$$



New cold source installed in 2002 has increased flux by 1.8

Overview of MACS



Beam Shutter aperture that Chromator

Cooled Be, PG, and Al₂O₃

super mirror guide channel

21 channel crystal analyzer

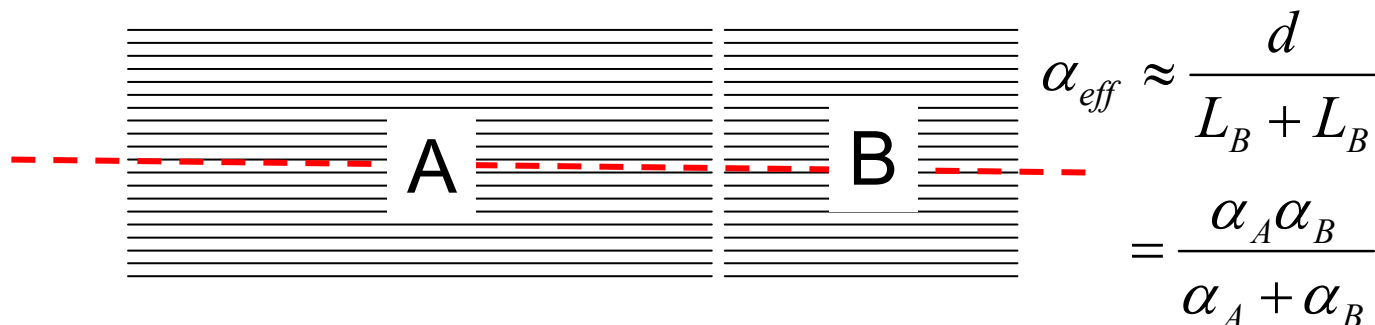
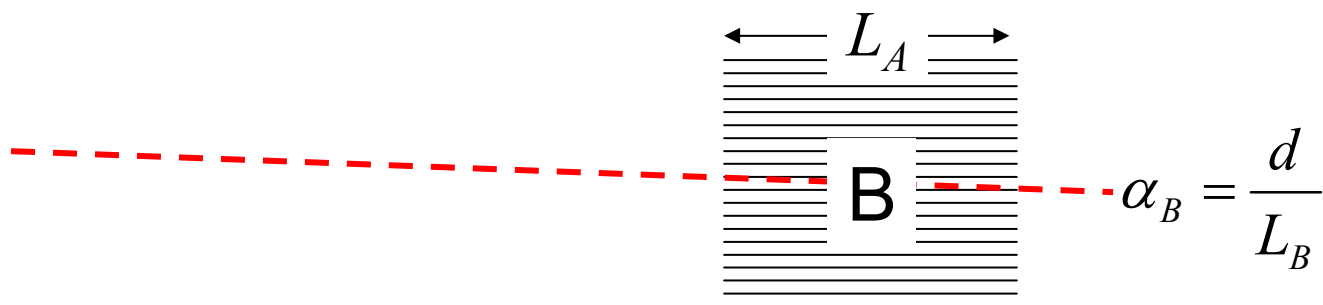
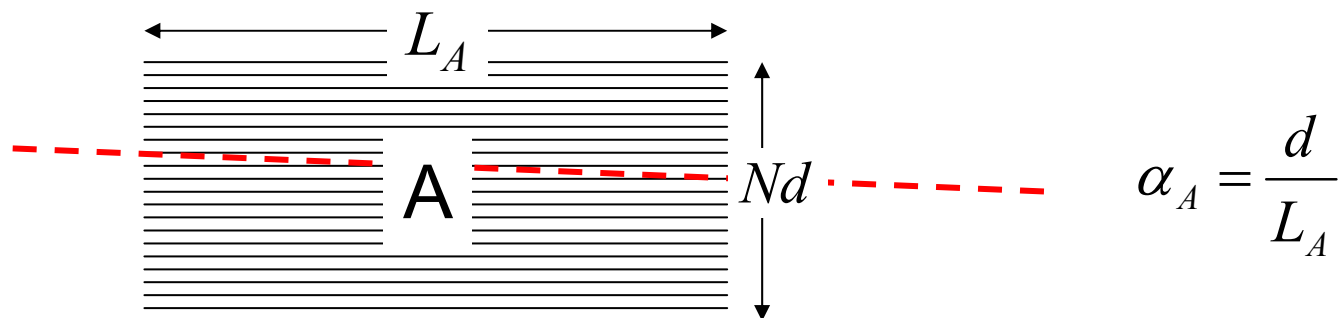


Incident beam filters

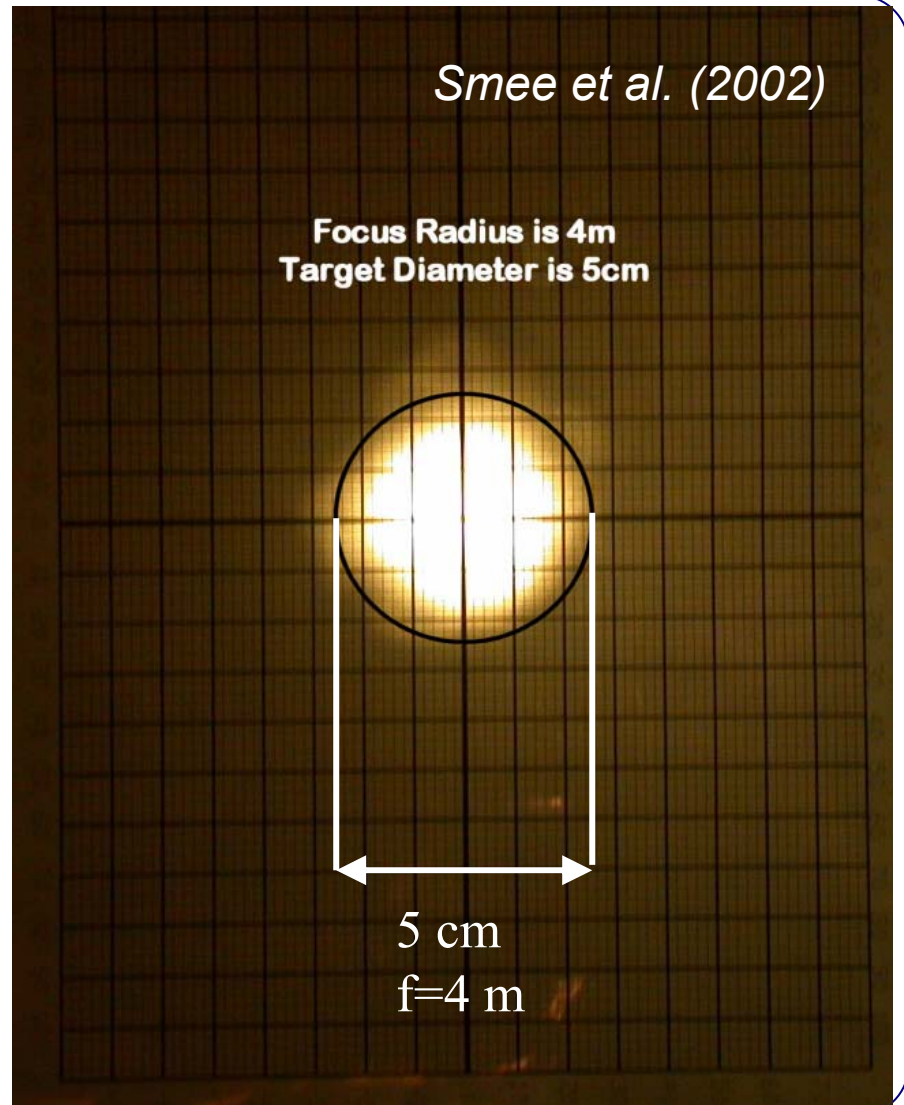
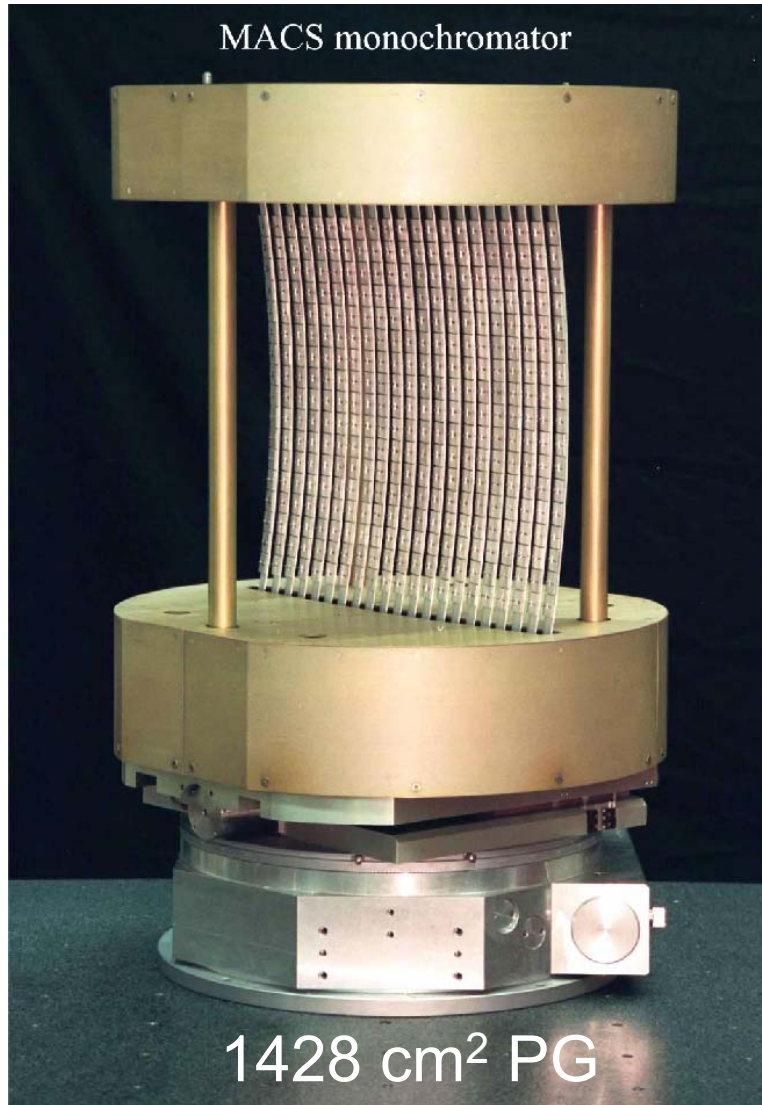
- PG filter (8 cm)
 - Order suppression at 13.7 meV and 14.7 meV
 - Fast neutron suppression $E < 15$ meV
- Be filter (10 cm)
 - Order suppression $E < 5$ meV
 - Fast neutron suppression $E < 5$ meV
- Sapphire filter (8 cm)
 - Fast neutron suppression $15 < E < 20$ meV



Collimators in series



MACS –a New High Intensity Cold Neutron Spectrometer at NIST





Incident Beam Line

- **Shielding Design of Incident Beam Portion of the Instrument:** MACS General Layout, MACS Monte Carlo
- **Beam Tube Design**
- **Shutter Design**
- **Cryo Filter Exchanger (CFX)**
- **In-Line Collimator Exchanger (ICX)**
- **Variable Beam Aperture (VBA)**
- **Super-mirror Guide (SMG)**

MACS General Layout

v.1 Plan View

Drawing Courtesy of S. Smee

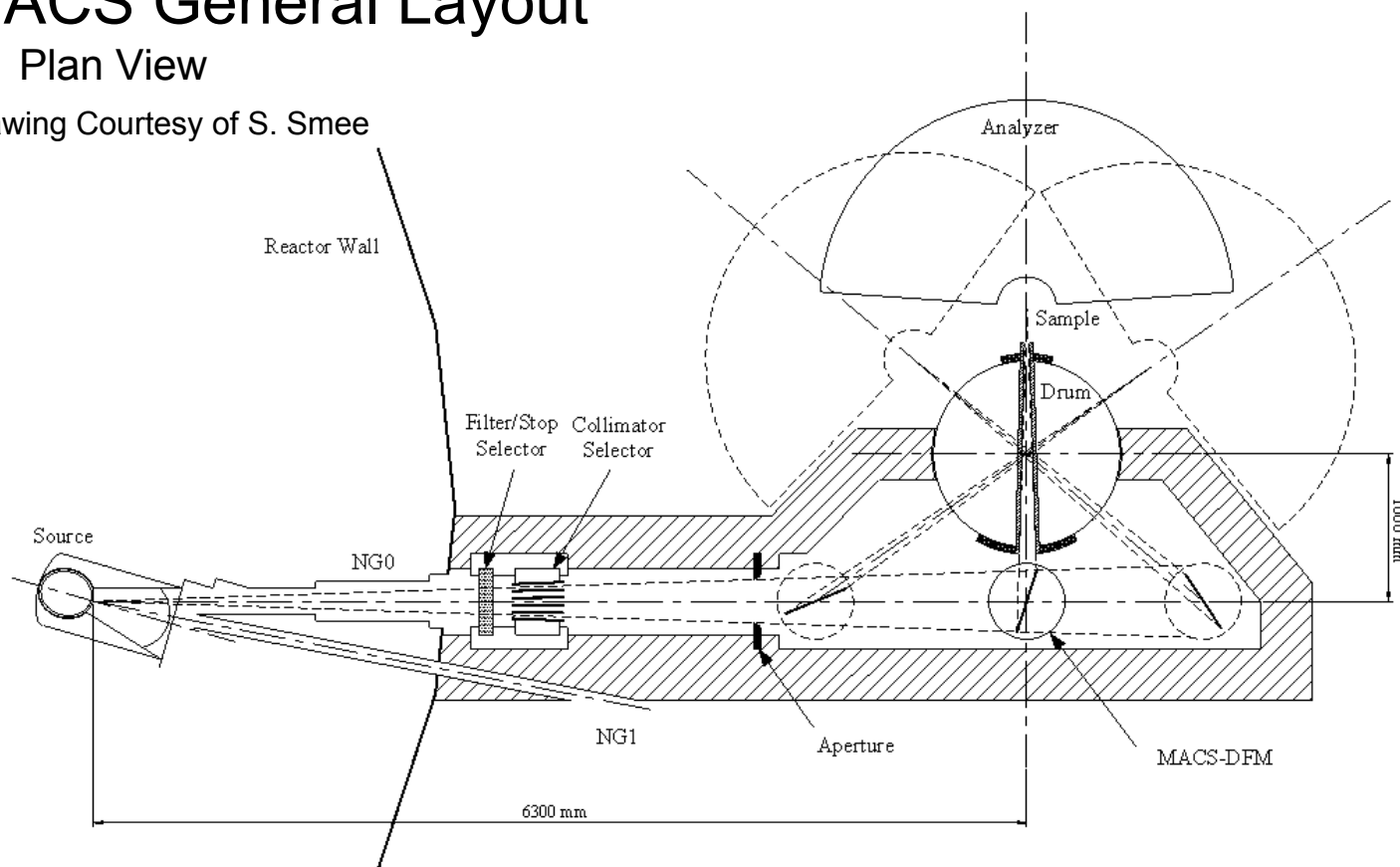
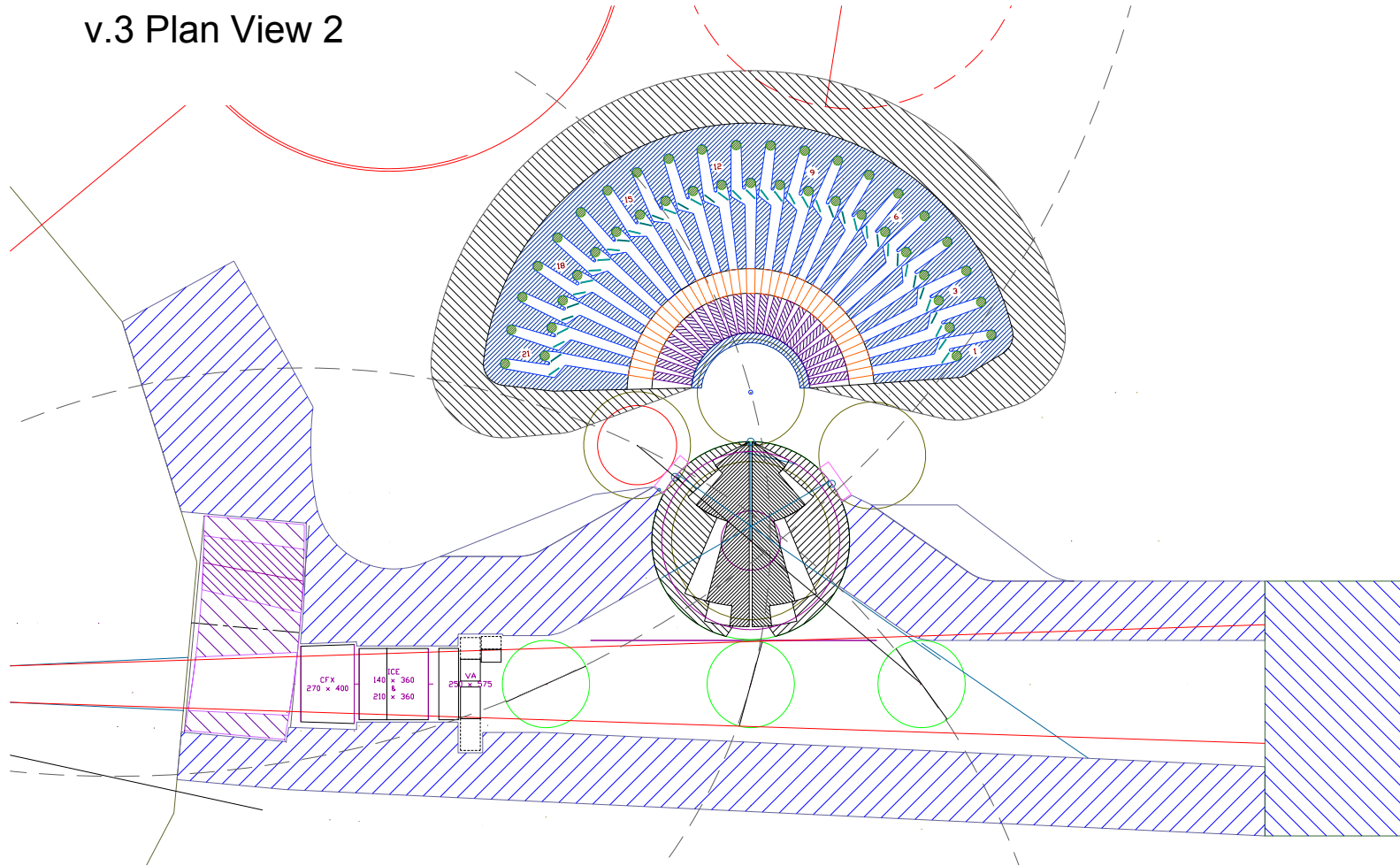


Fig. 3.1 Schematic of the Multi-Analyzer Crystal Spectrometer at the NIST Center for Neutron Research. The instrument views the cold source through the NG0 beam port.



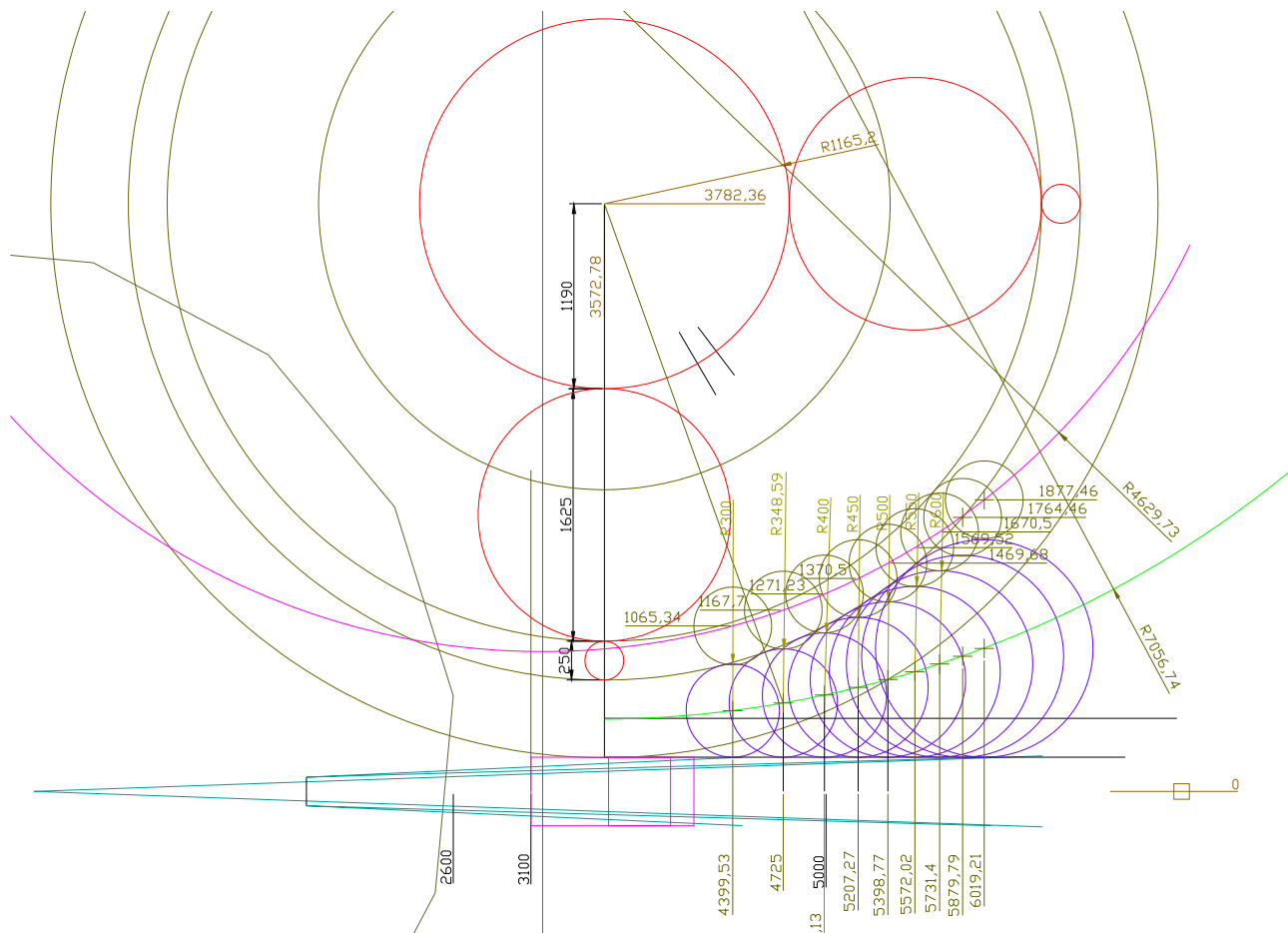
MACS General Layout

v.3 Plan View 2



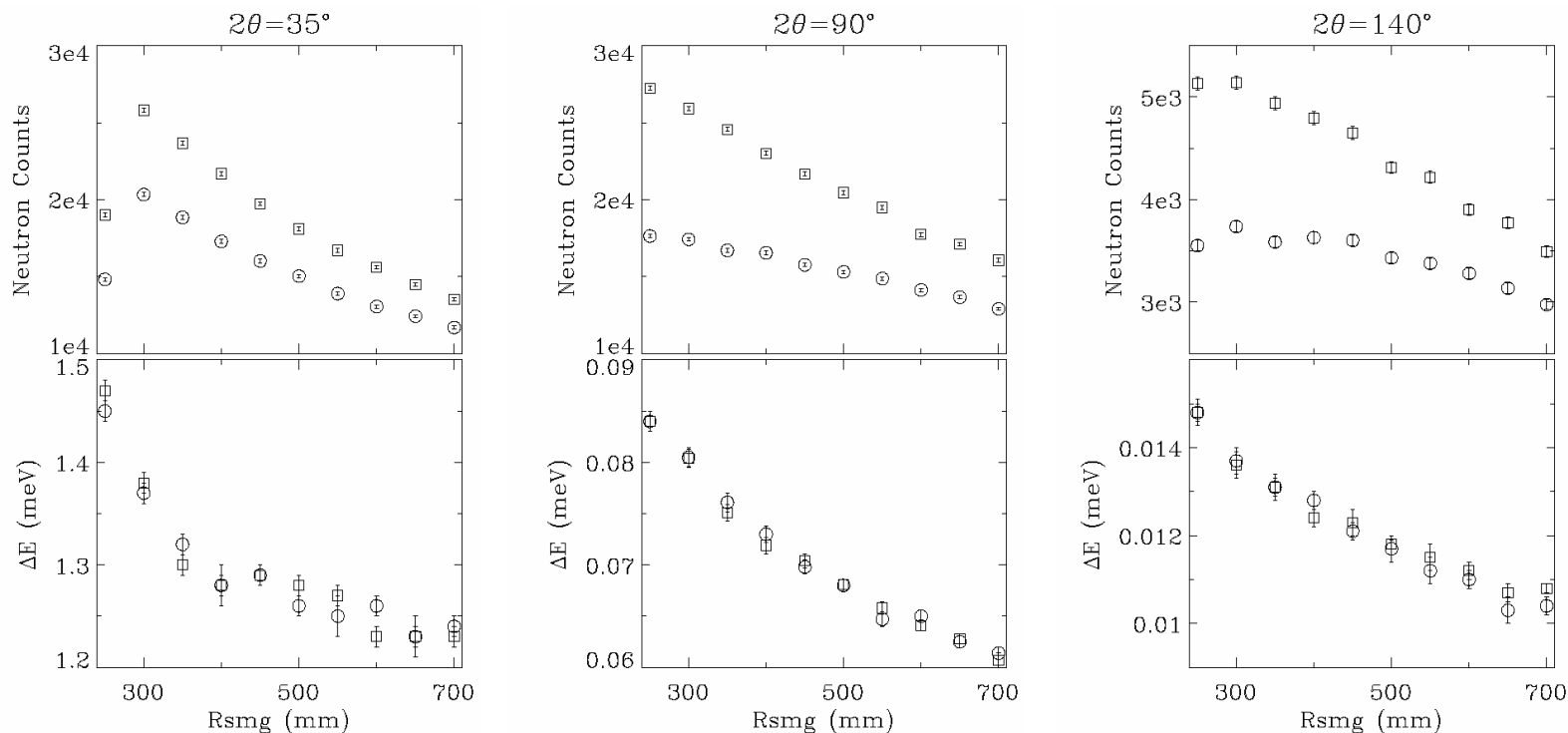


MACS General Layout Optimization





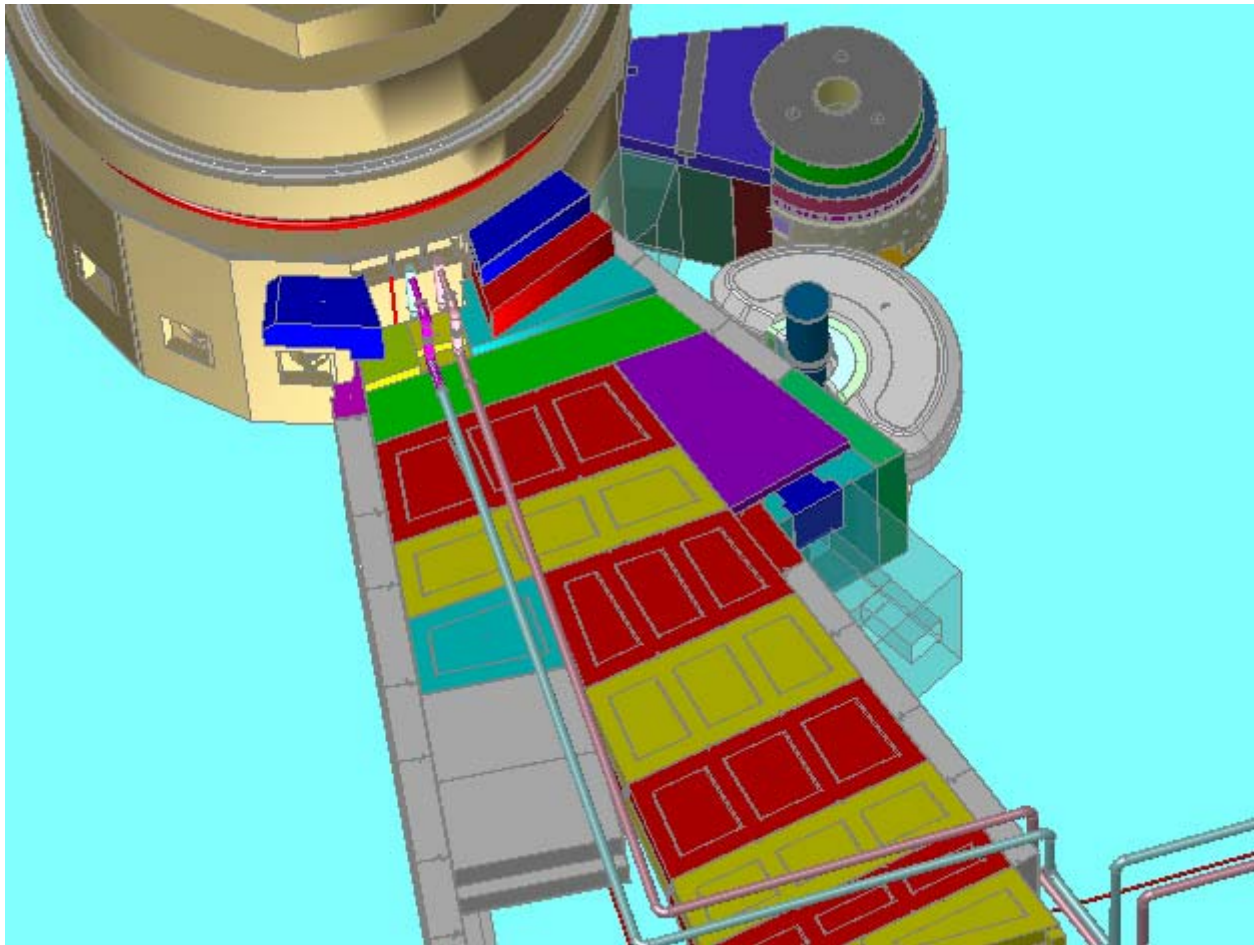
MACS Monte Carlo Beam Optimization (Radius SMG)





MACS General Layout

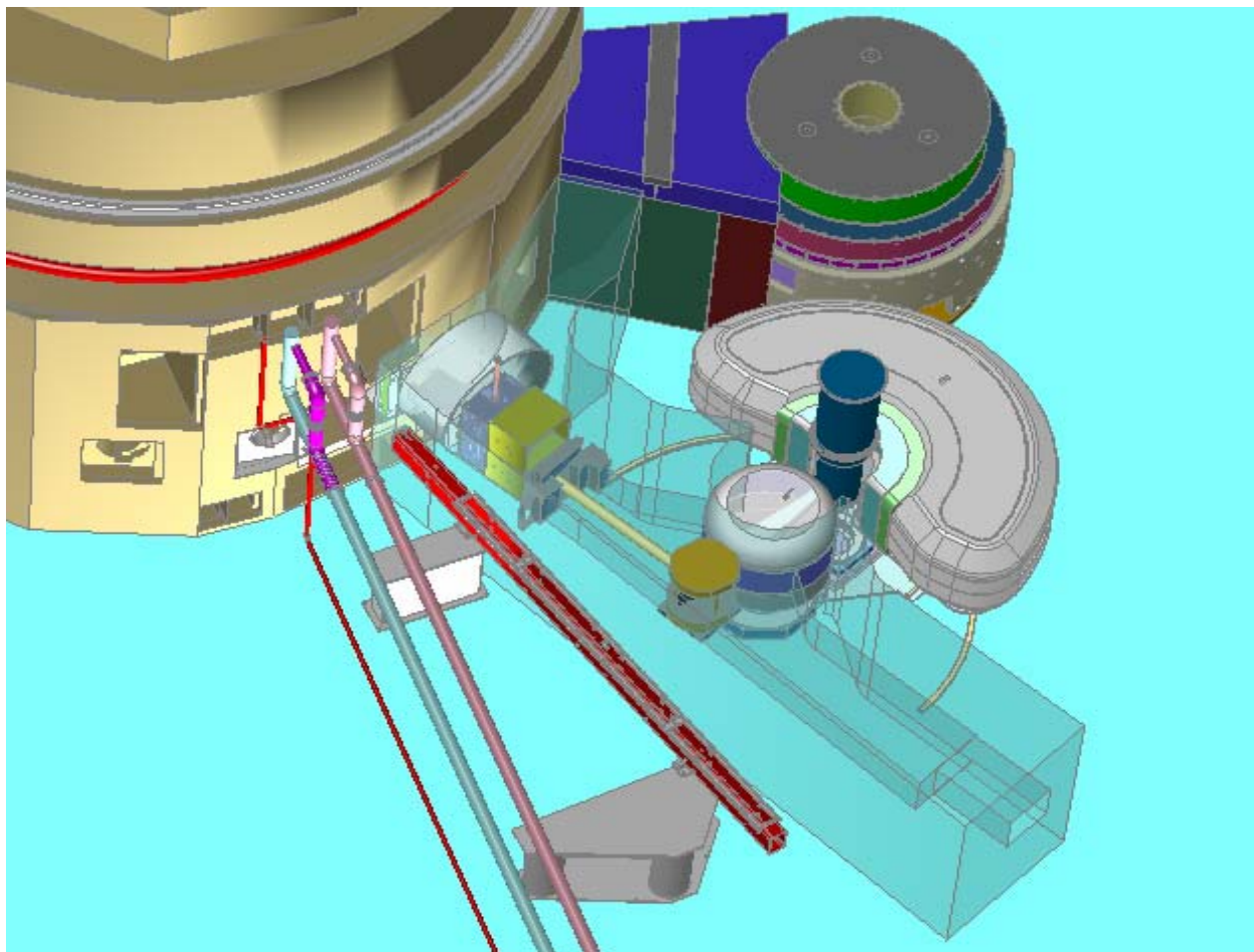
C-100 Perspective 1





MACS General Layout

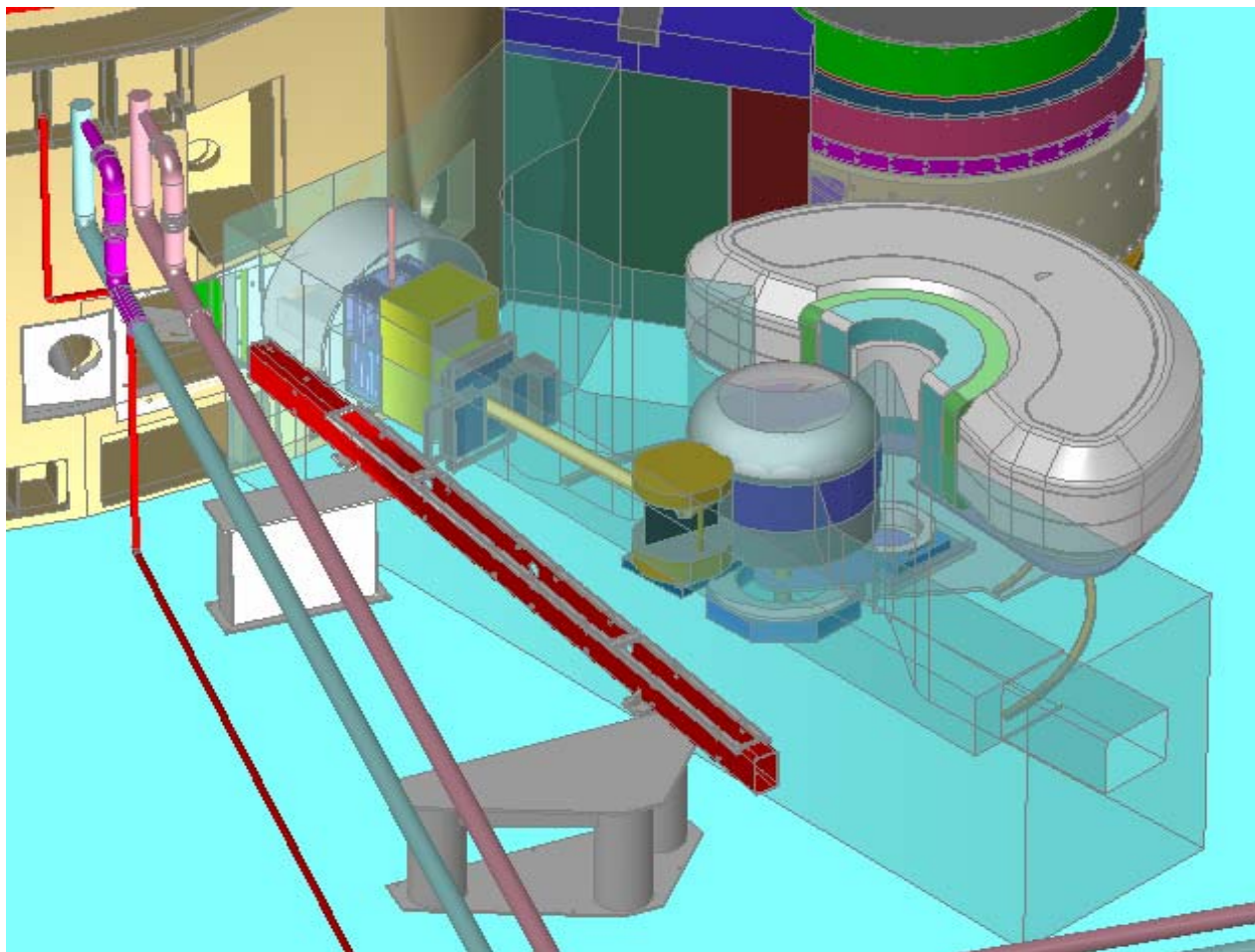
C-100 Perspective 2





MACS General Layout

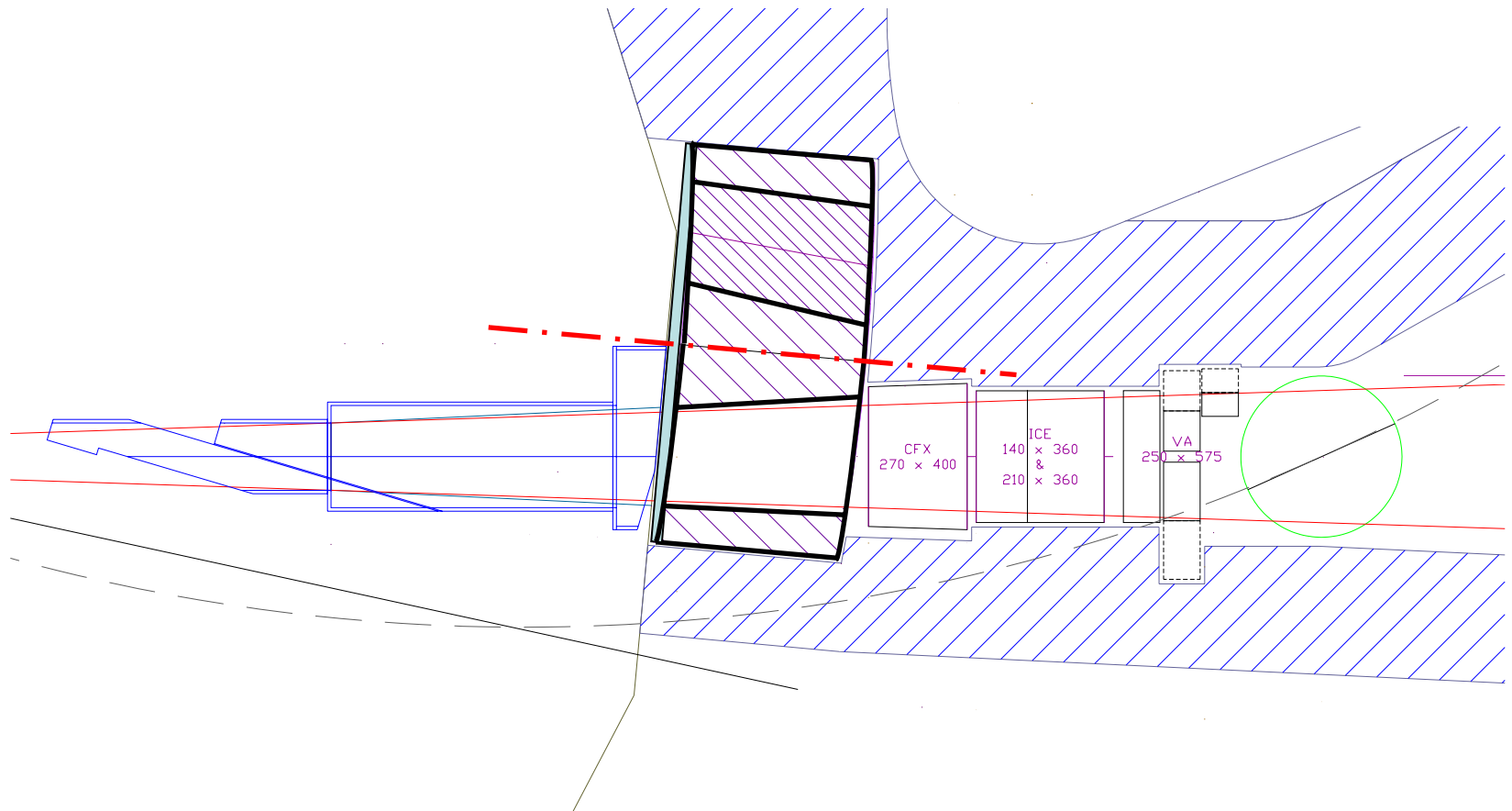
MACS Perspective





MACS Shutter

Plan View



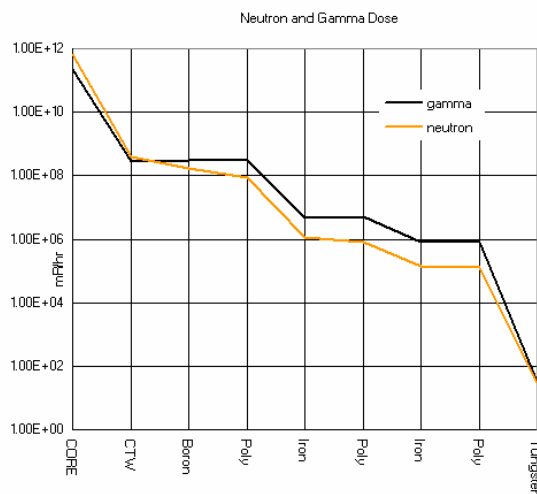
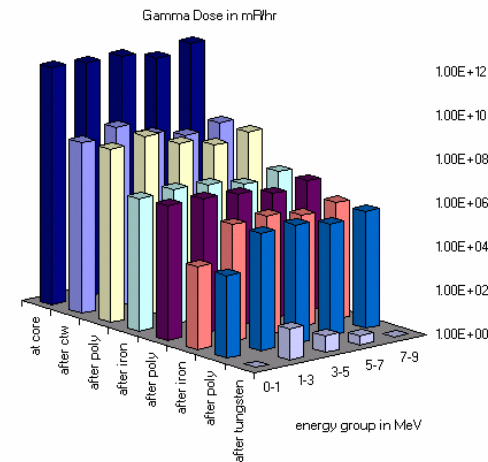
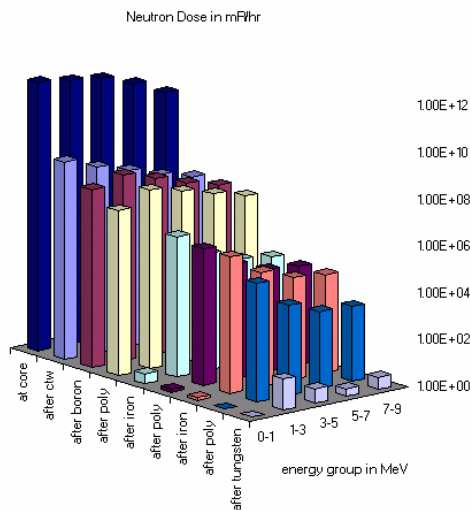


MACS Shutter Calculation Results

Excel Spreadsheet Courtesy of C. Brocker

CB Ref Values

Shutter	Layer	Neutron	Gamma
Layer	Thickness	Dose	Dose
	in cm	mR/hr	mR/hr
CORE		6.58E+11	2.15E+11
CTW		4.00E+08	2.76E+08
Boron	0.25	1.68E+08	2.92E+08
Poly	2.50	8.75E+07	2.92E+08
Iron	18.00	1.13E+06	4.87E+06
Poly	1.50	7.96E+05	5.06E+06
Iron	8.00	1.36E+05	8.32E+05
Poly	0.25	1.28E+05	8.31E+05
Tungsten	19.50	30.4	34.4
Total	50.00		70.00
Thickness			



Boron	0.25	0.25	0.25	0.25	0.25
Poly	2.00	2.00	2.50	2.50	2.50
Iron	15.50	16.00	16.00	16.00	17.00
Poly	0.50	0.50	0.50	1.00	1.00
Iron	8.00	8.00	8.00	8.00	8.00
Poly	0.25	0.25	0.25	0.25	0.25
Tungsten	19.00	19.00	19.00	19.00	19.00

Total	45.50	46.00	46.50	47.00	48.00
Neutron	93.2	82.8	74.5	67	52.8
Gamma	99.4	86.7	76.2	67	51.1

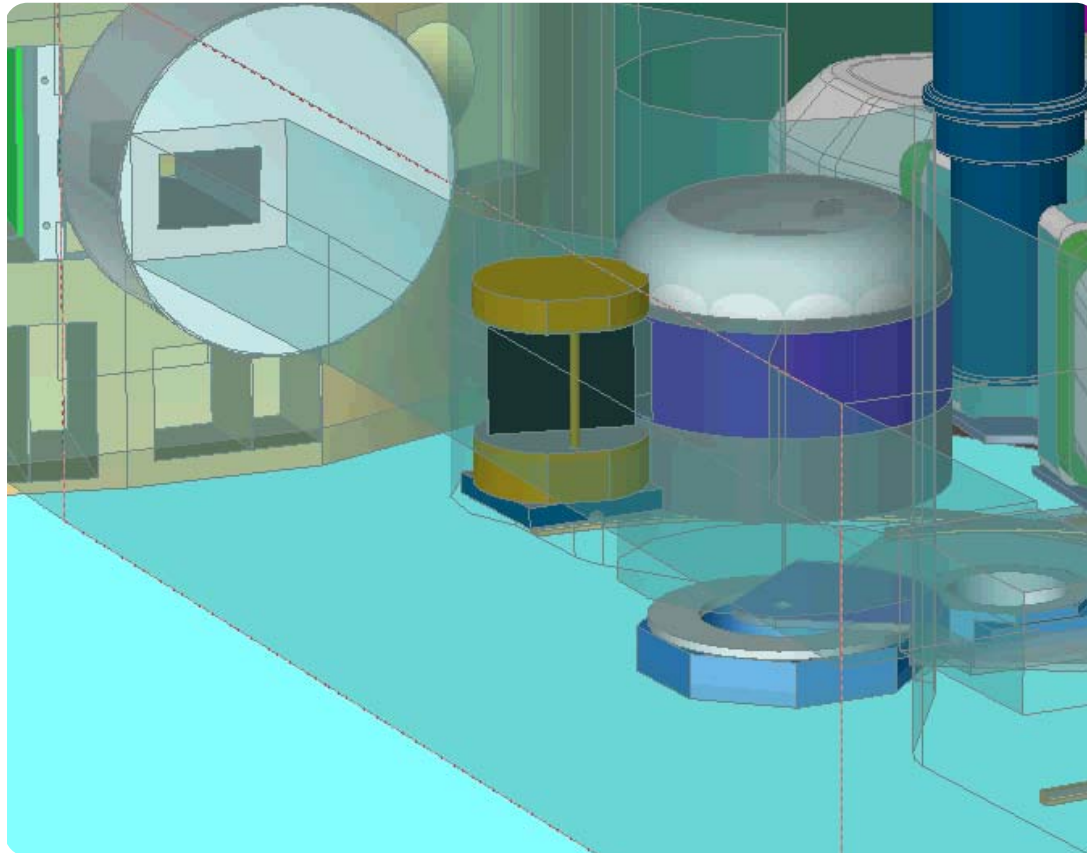
0.25	0.25	0.25	0.50	1.00	1.00
2.50	2.50	2.50	2.50	4.00	3.00
17.50	18.00	19.00	19.00	20.00	25.00
1.50	1.50	2.00	2.50	3.00	3.00
8.00	8.00	8.00	8.00	8.00	15.00
0.25	0.25	0.25	2.50	3.00	3.00
19.00	19.50	20.00	20.00	21.00	20.00

49.00	50.00	52.00	55.00	60.00	70.00
42.2	30.4	17.5	10	3.2	0.3
39.3	34.4	23.2	11.7	4.9	0.3



MACS Shutter

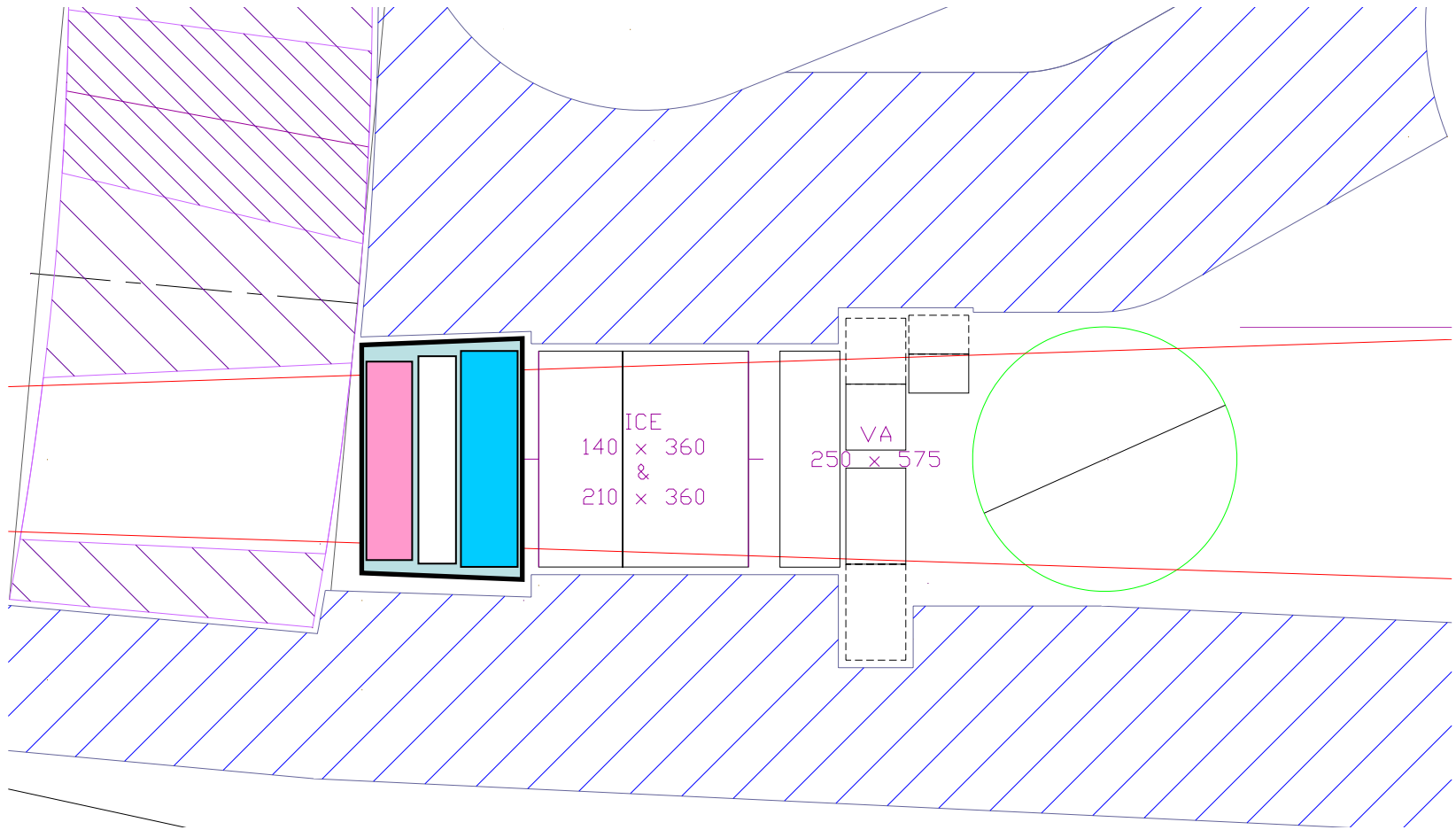
Perspective





Cryo Filter Exchanger (CFX)

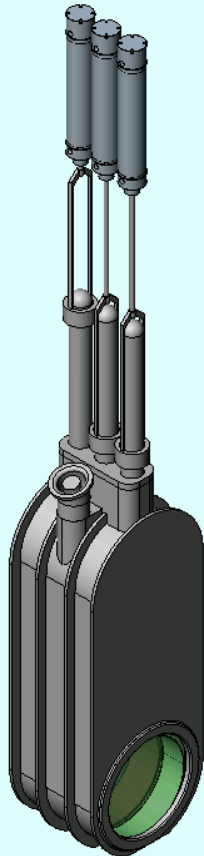
Plan View Reference



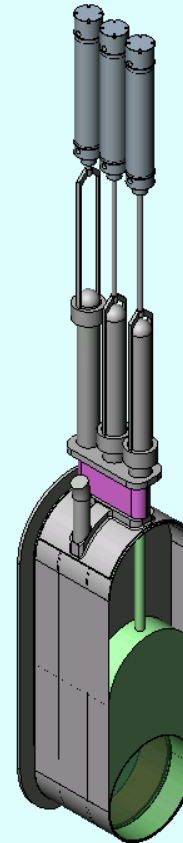
Cryo Filter Exchanger (CFX)

Perspective

Complete
Assembly



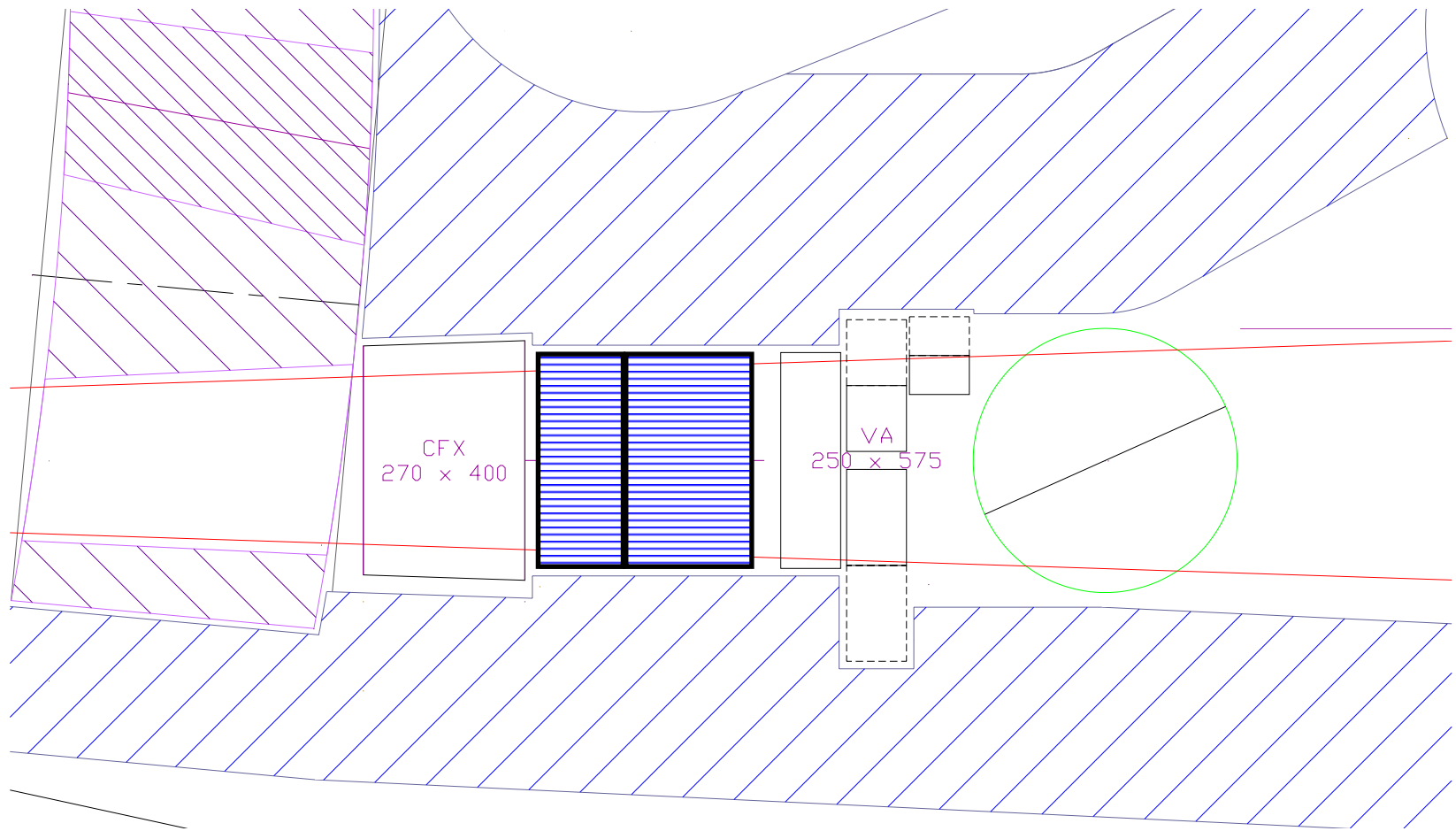
Cut-Away
View





In-Line Collimator Exchanger (ICX)

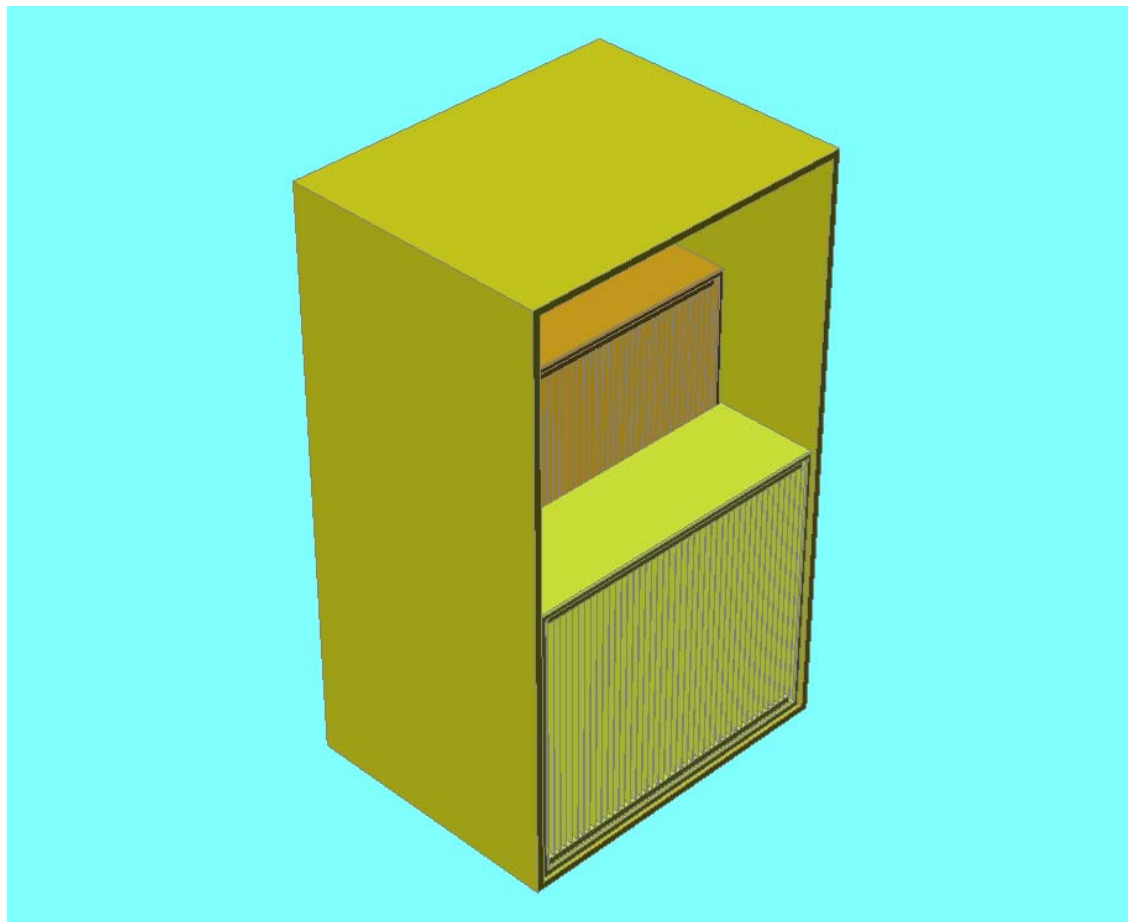
Plan View Reference





In-Line Collimator Exchanger (ICX)

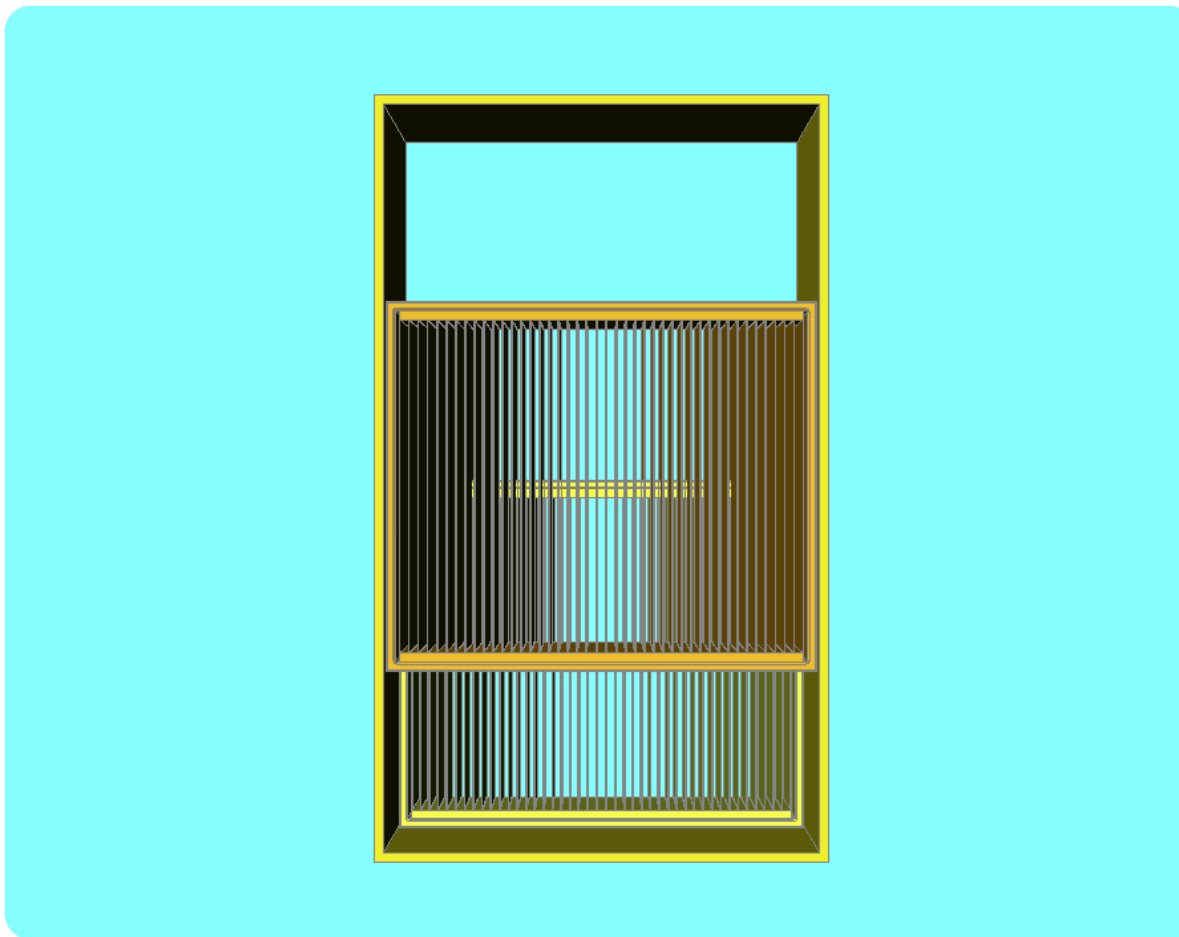
Perspective 1





In-Line Collimator Exchanger

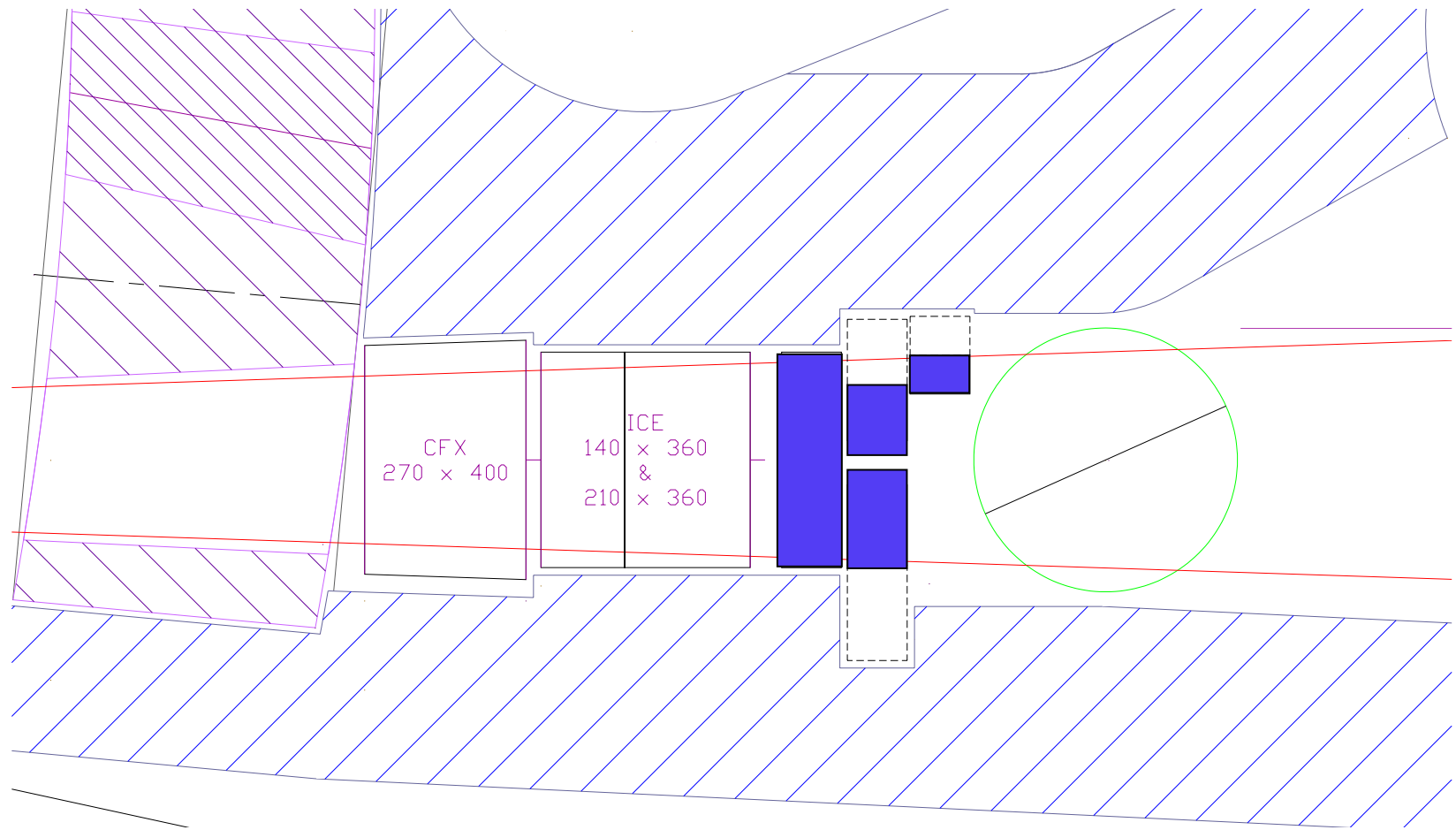
Perspective 2





Variable Beam Aperture (VBA)

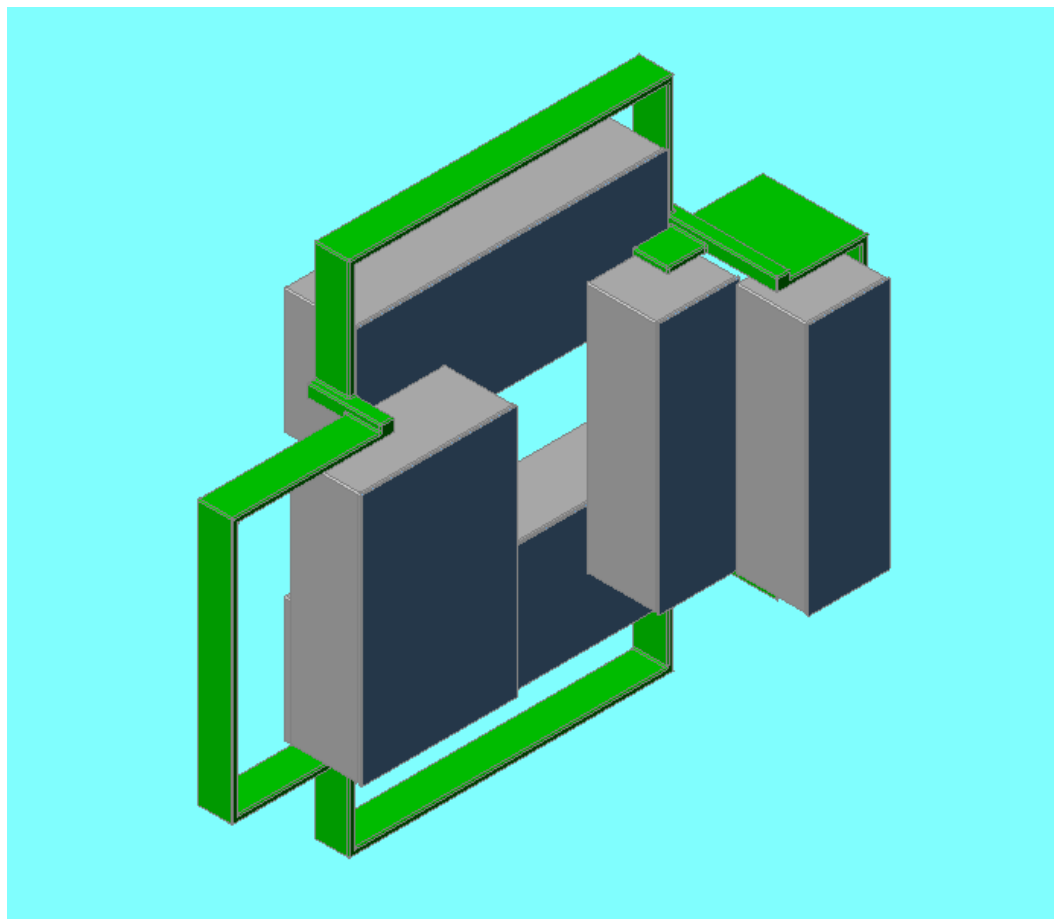
Plan View Reference





Variable Beam Aperture

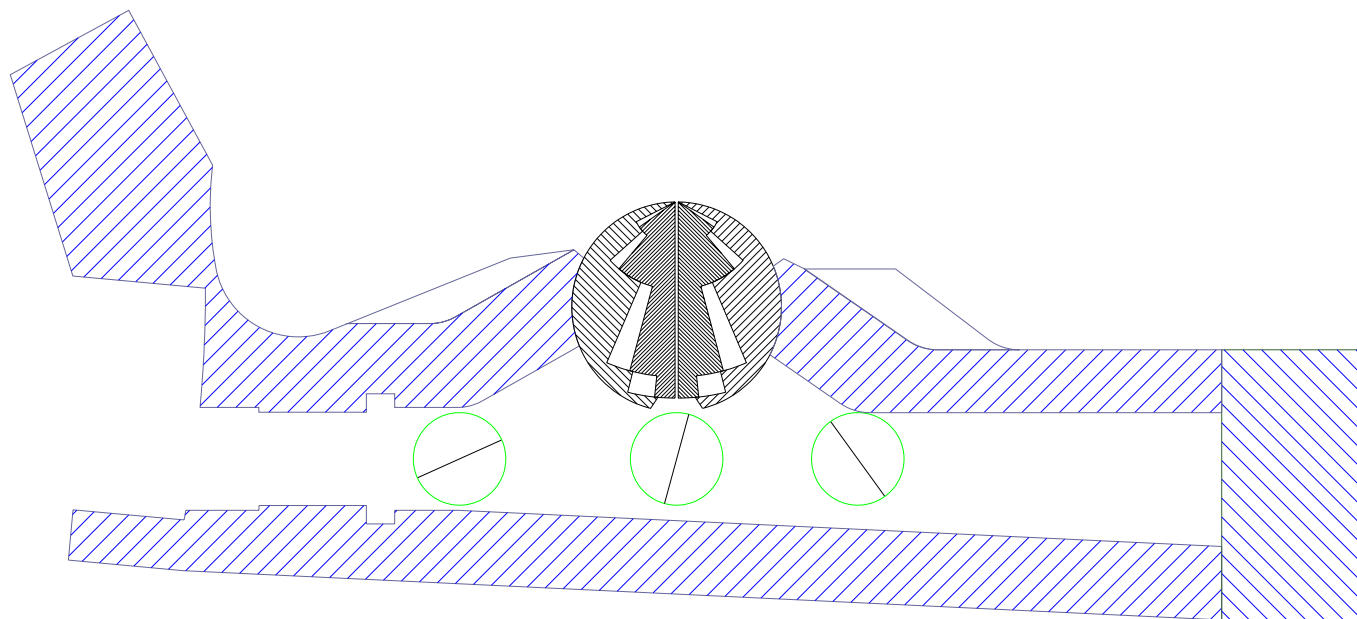
Perspective





Super-mirror Guide (SMG)

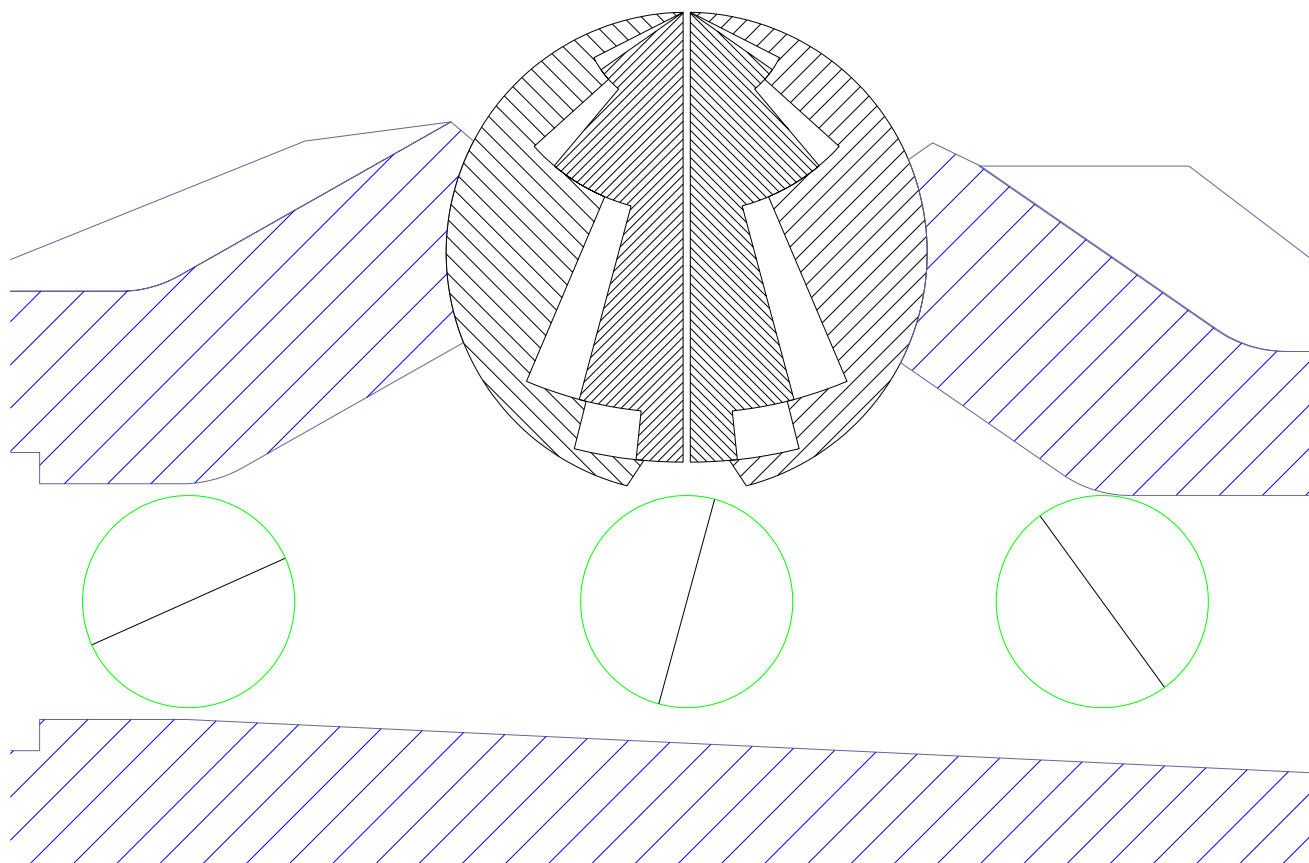
Plan View Reference 1





Super-mirror Guide (SMG)

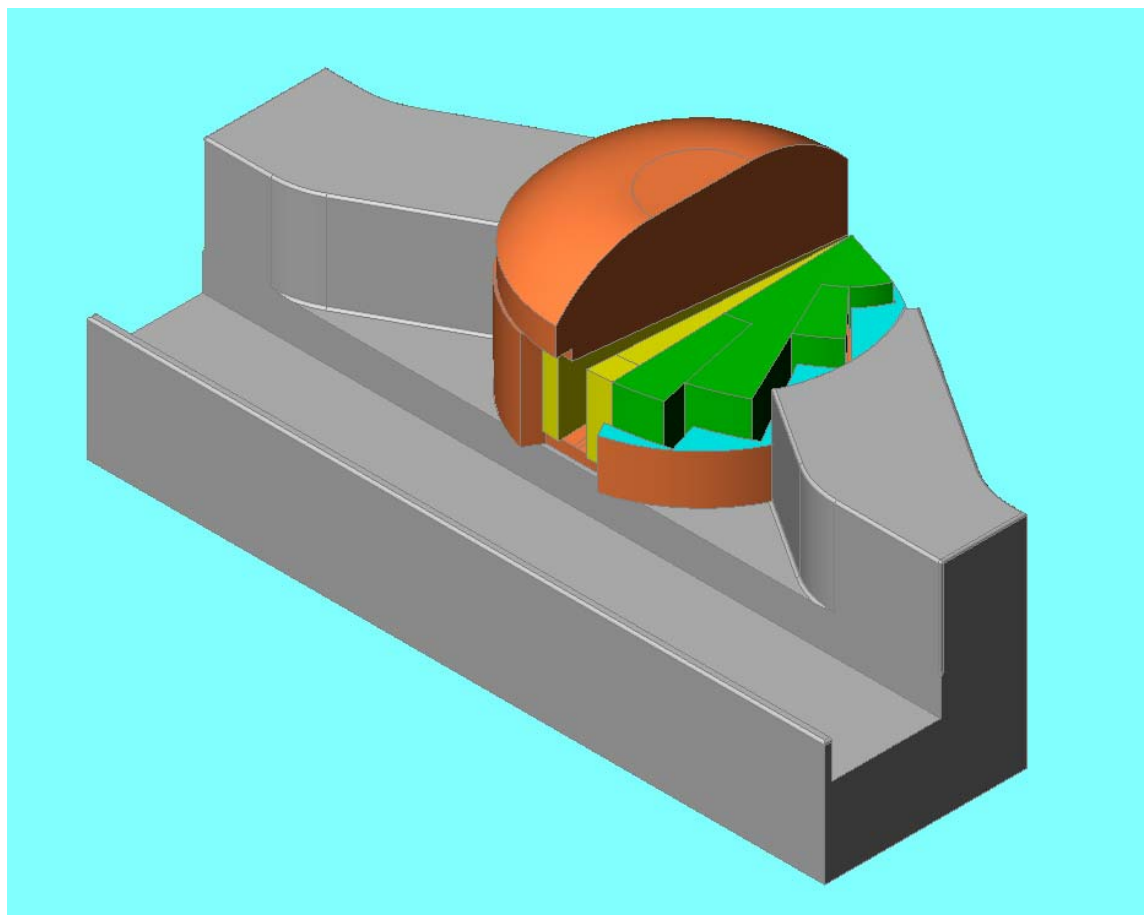
Plan View Reference 2





Super-mirror Guide (SMG)

Perspective 1



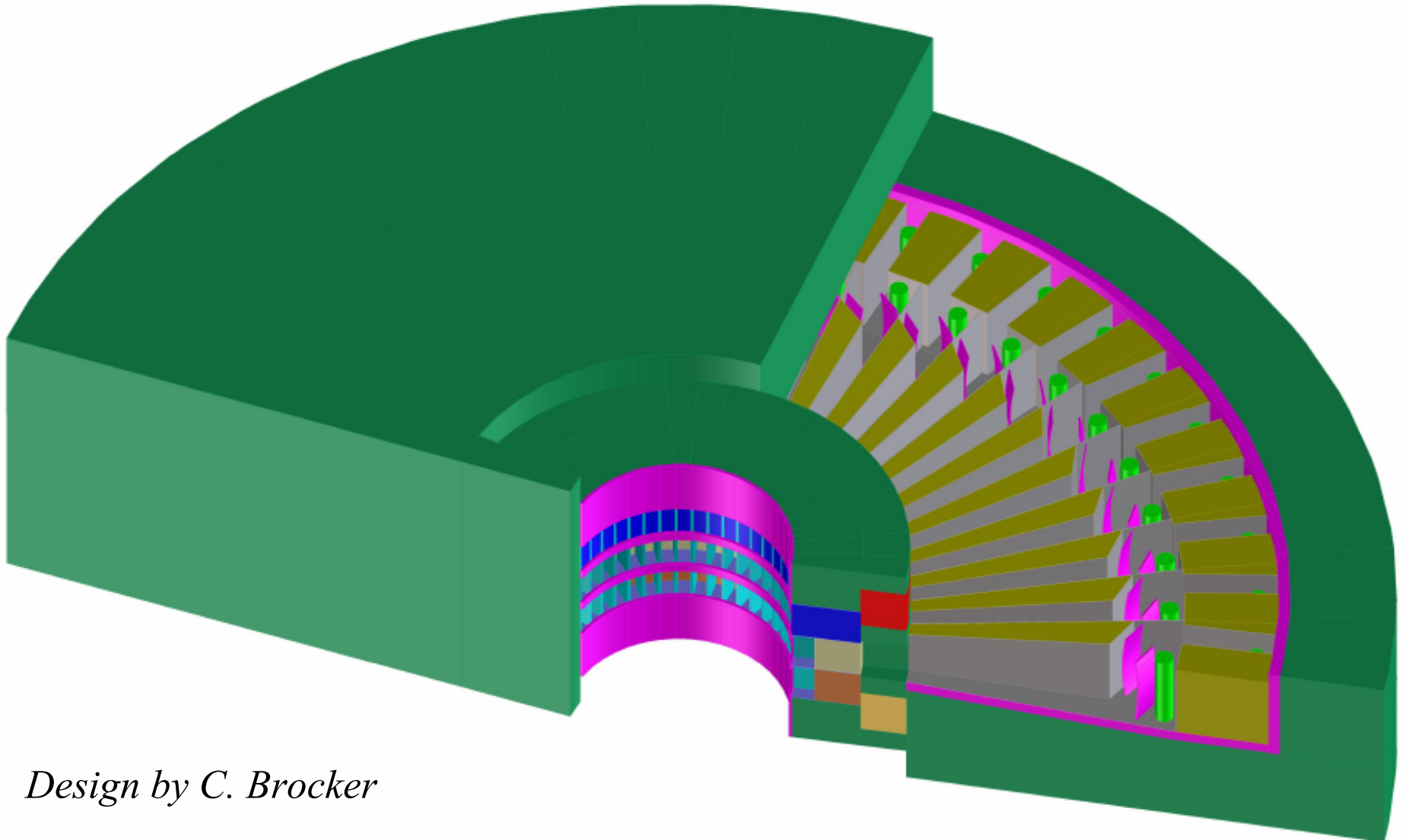


Detector

- **Detection System Shielding**
- **Detector System Motion Control**
- **Post Sample Filter Exchanger**
- **Post Sample Collimator Exchanger**
- **Double Crystal Analyzer Linkage**



Twenty-one Channel Analyzer System



Design by C. Brocker



"TAS" detector

Collimator 1

Energy integrating
Detector

8° vertically focusing
Analyzer crystals

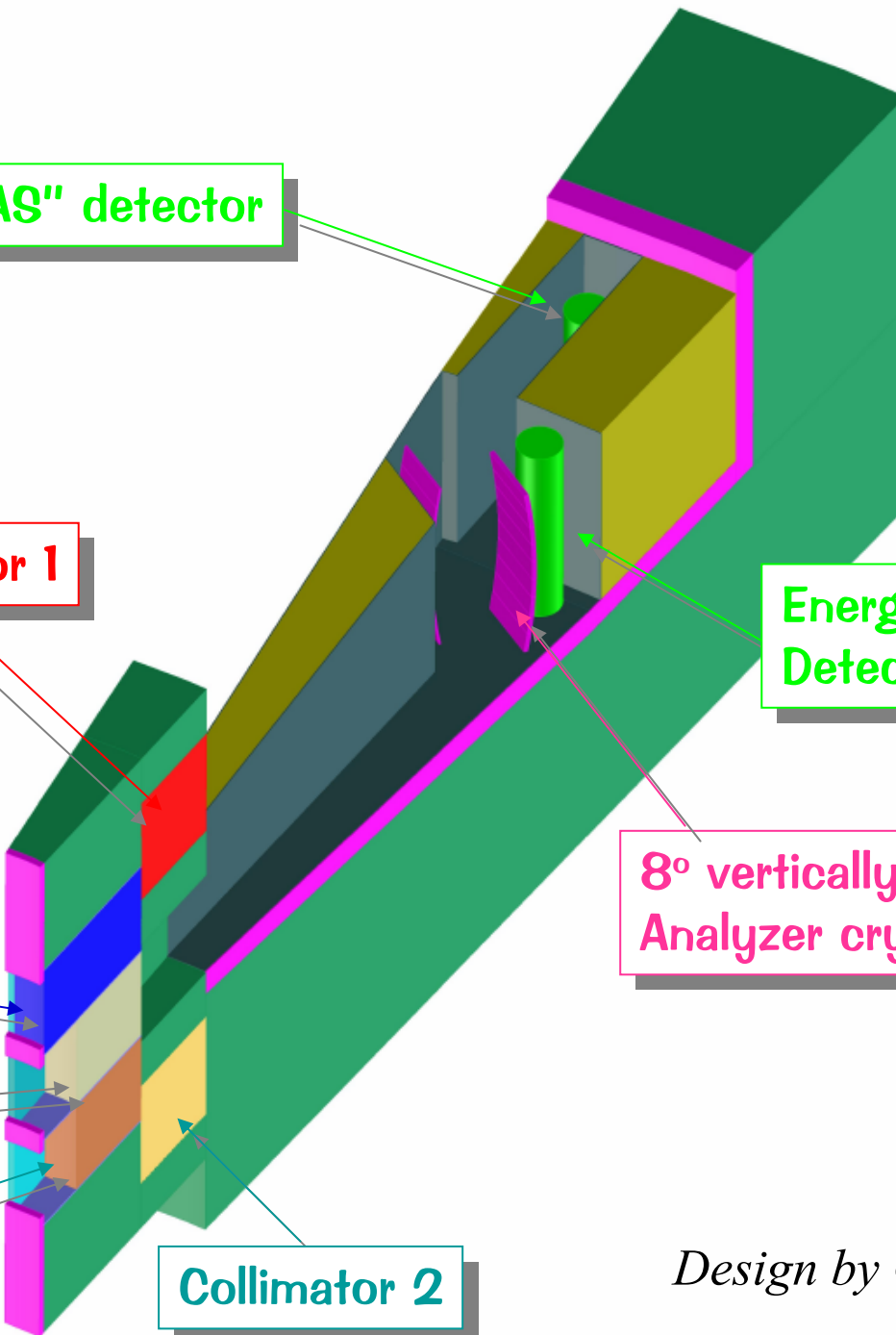
BeO filter

Be filter

PG filter

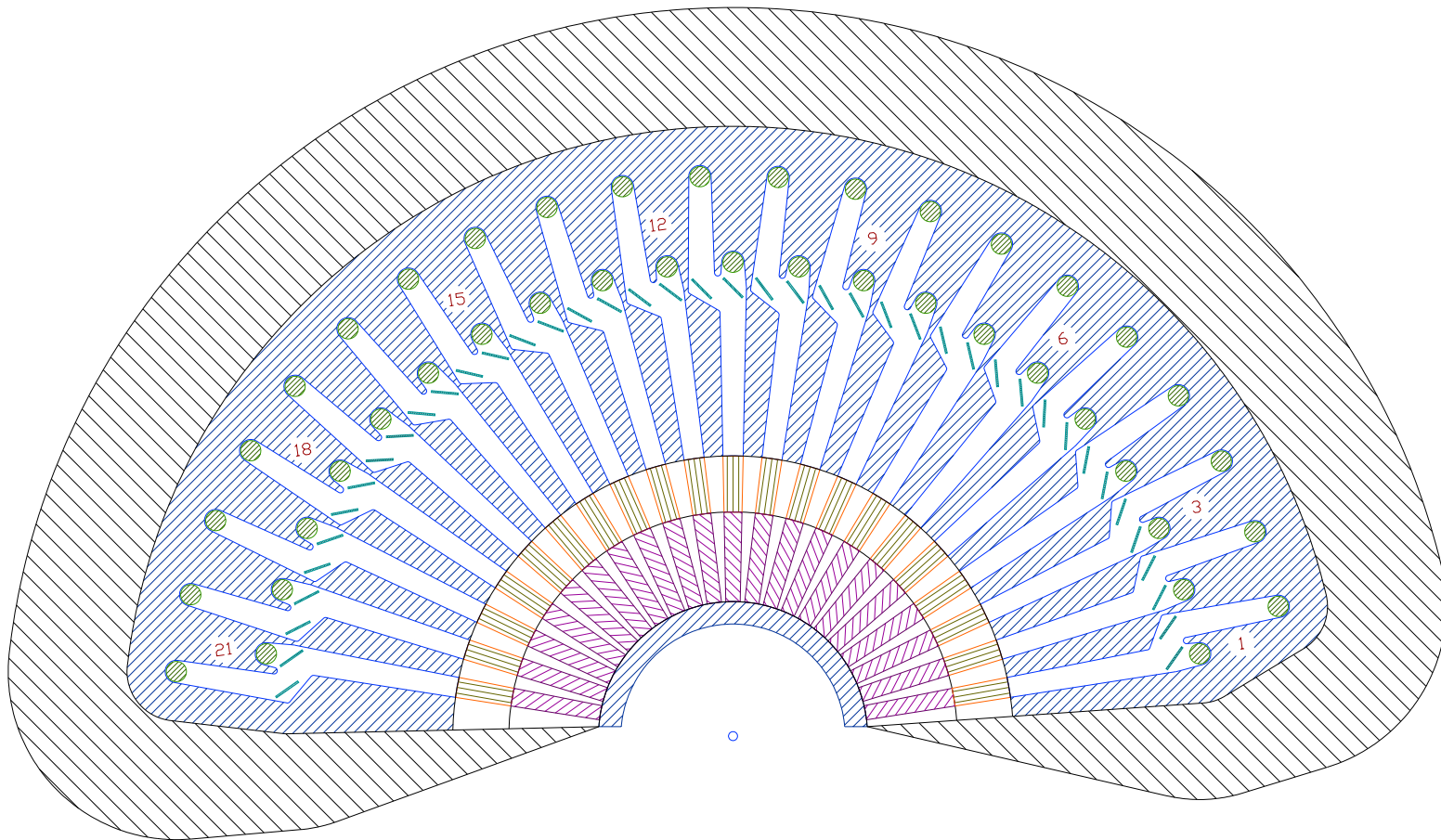
Collimator 2

Design by C. Brocker



Detector Shielding

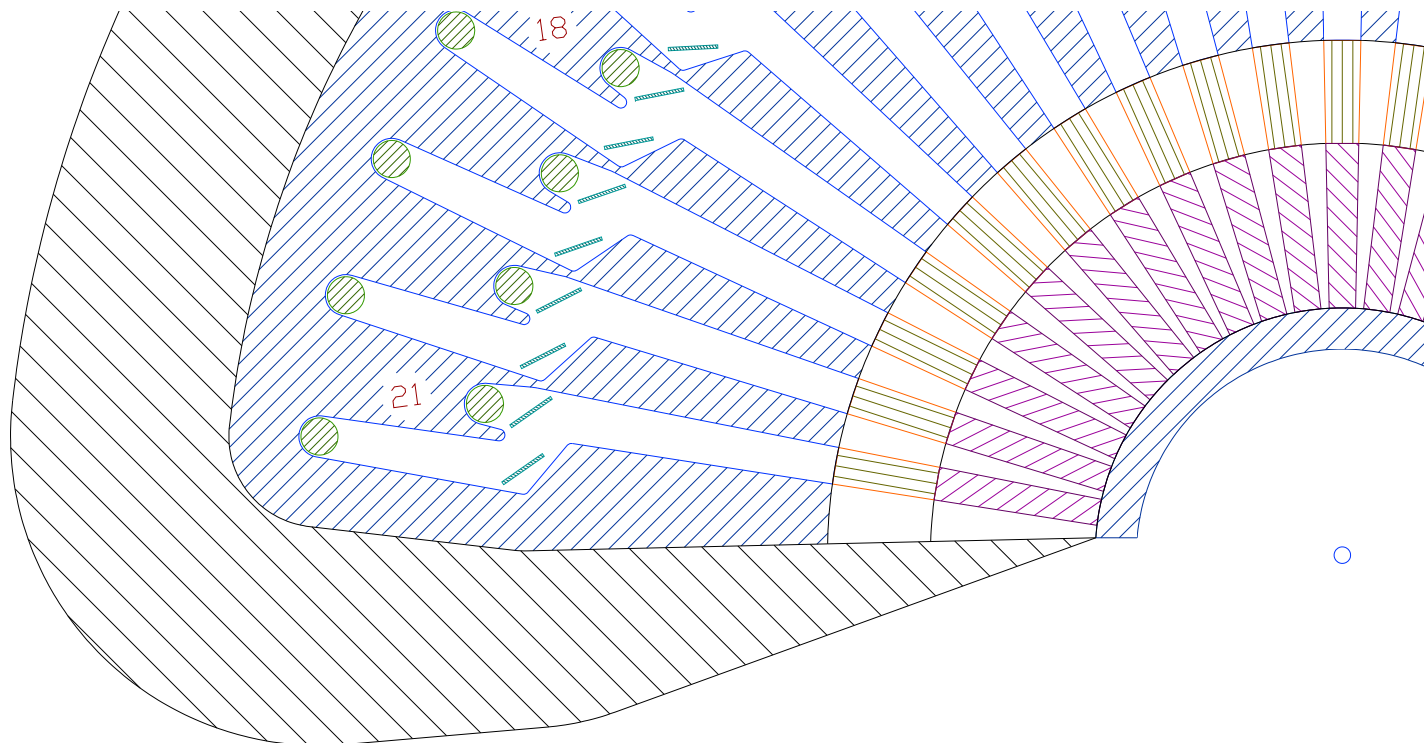
Plan View 1





Detector Shielding

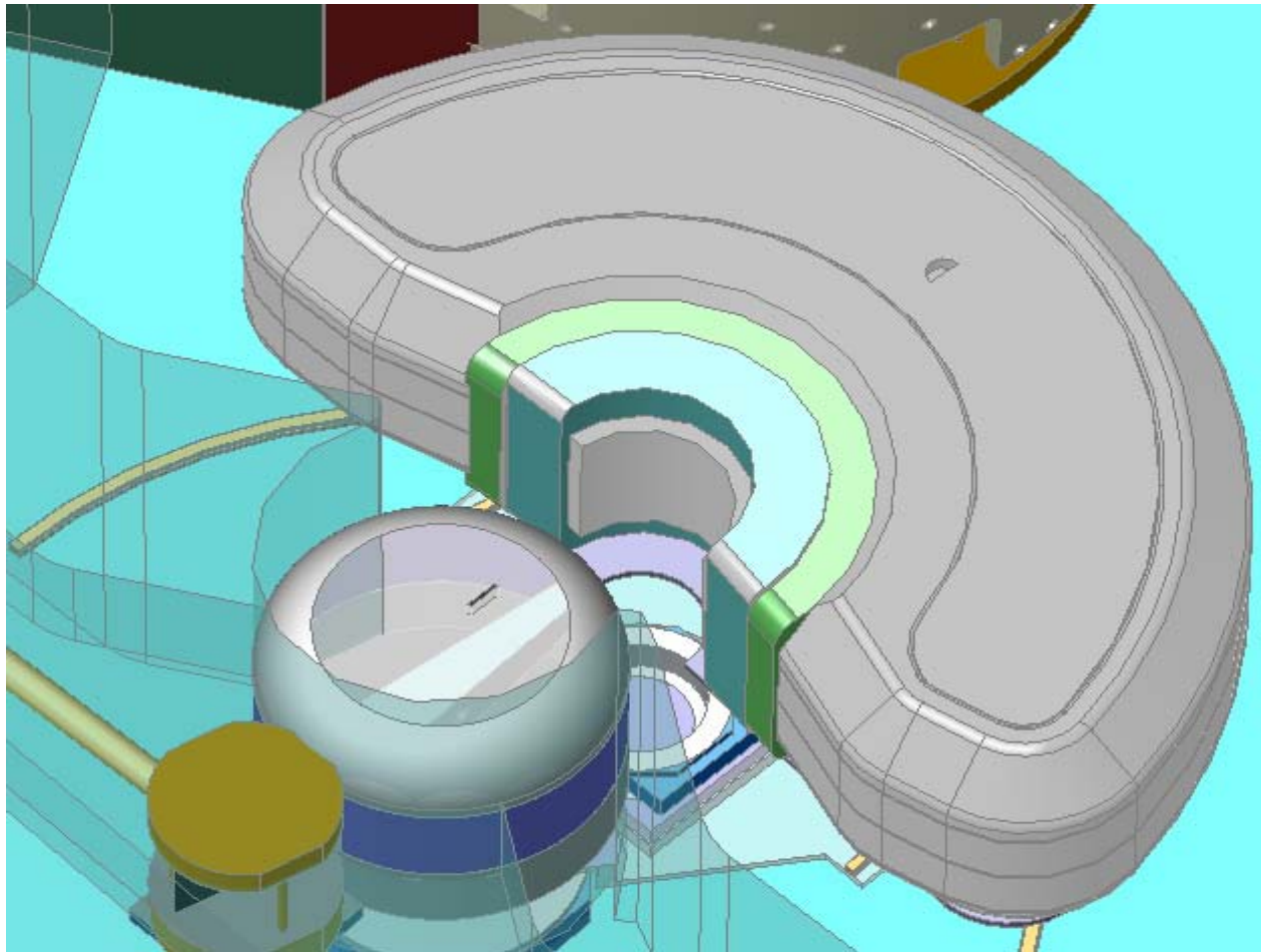
Plan View 2





Detector Shielding

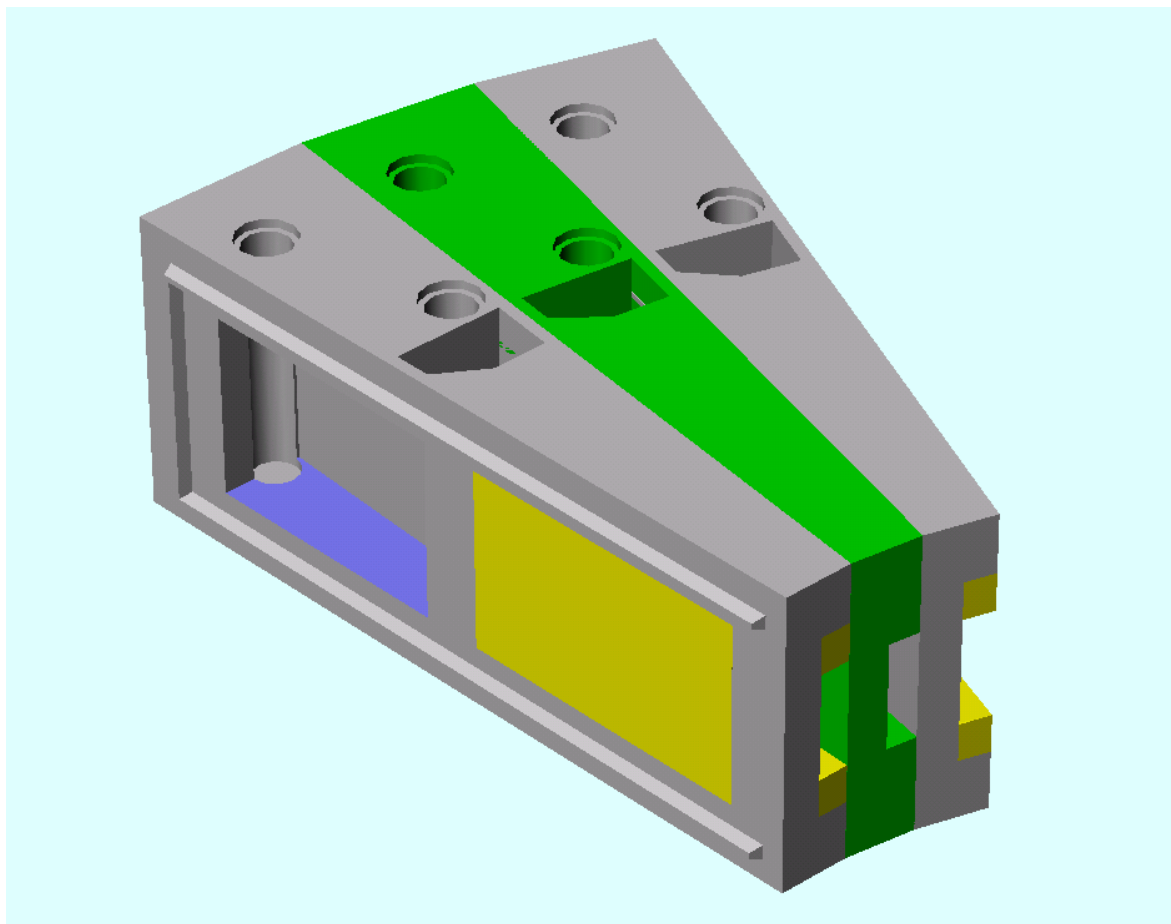
Perspective





Detector Shielding Multiple Segments

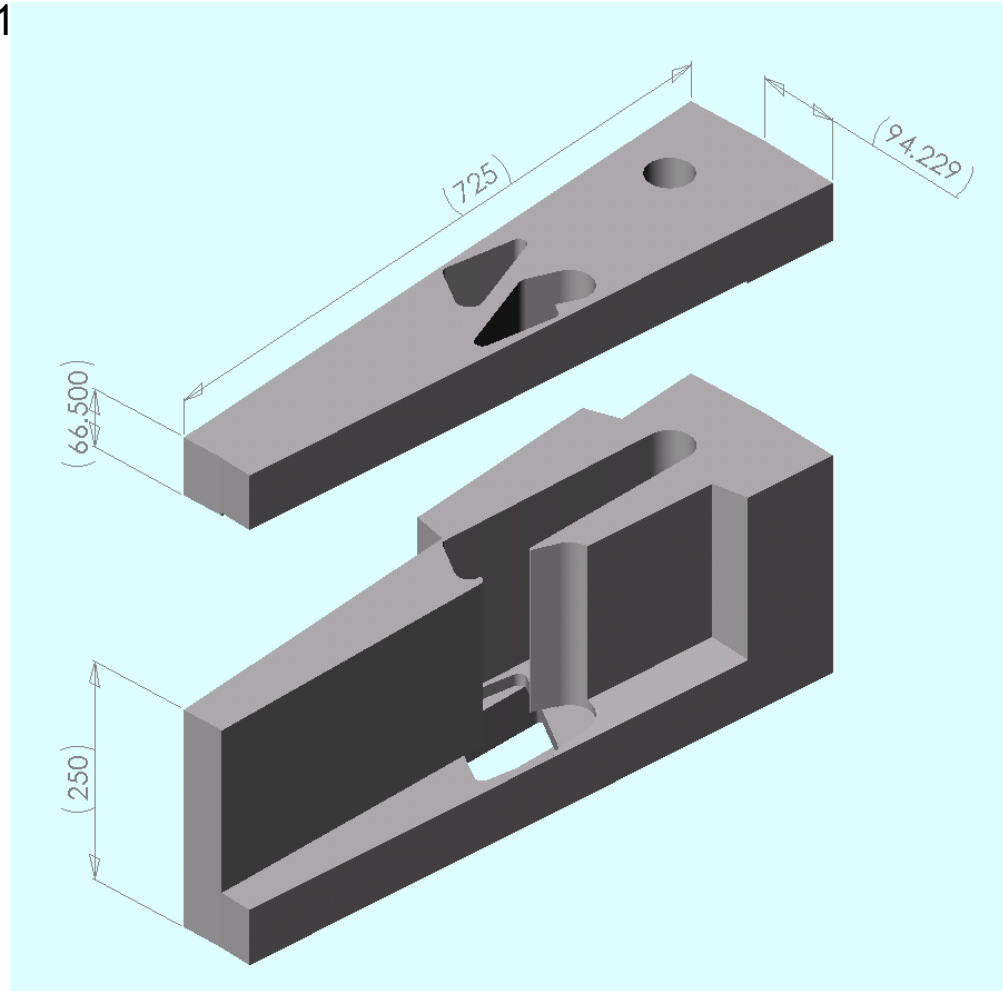
Perspective 2





Detector Shielding Segment Construction

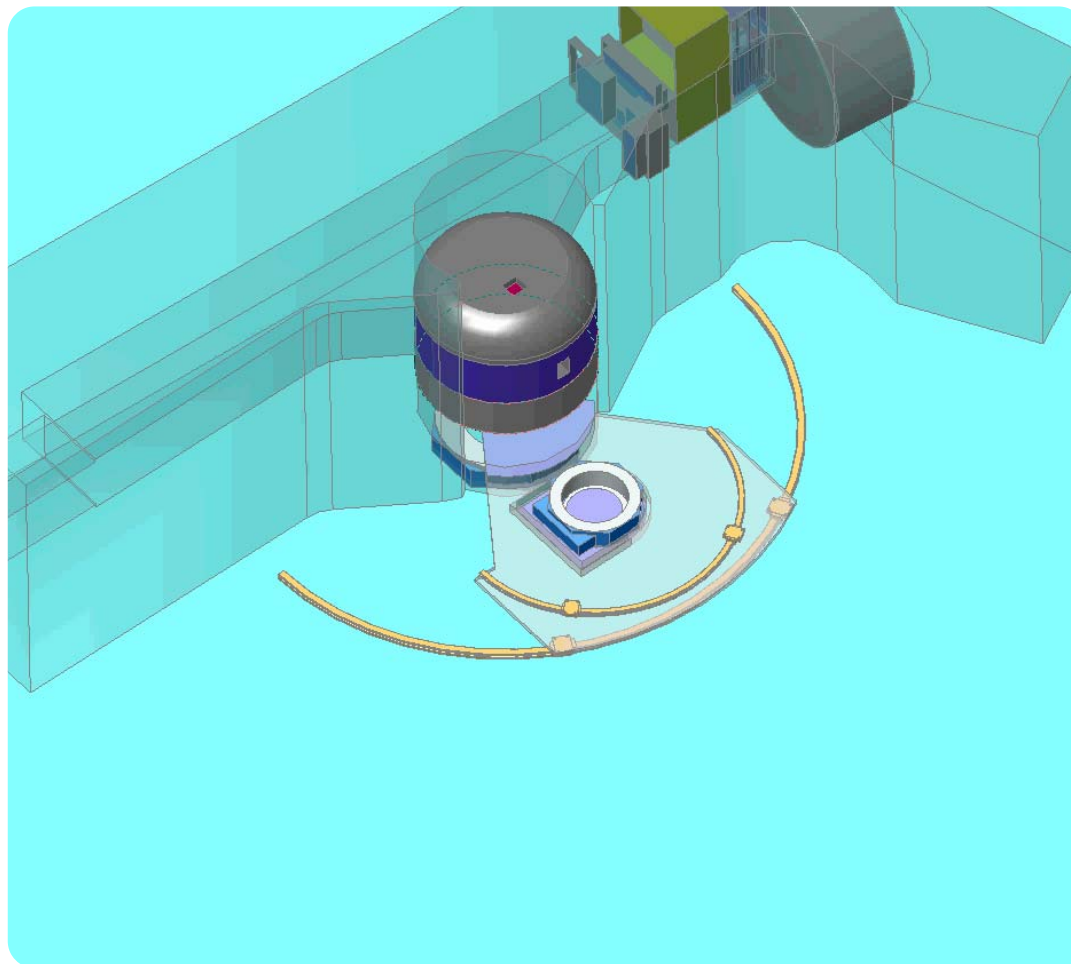
Perspective 1





Detector System Motion Control

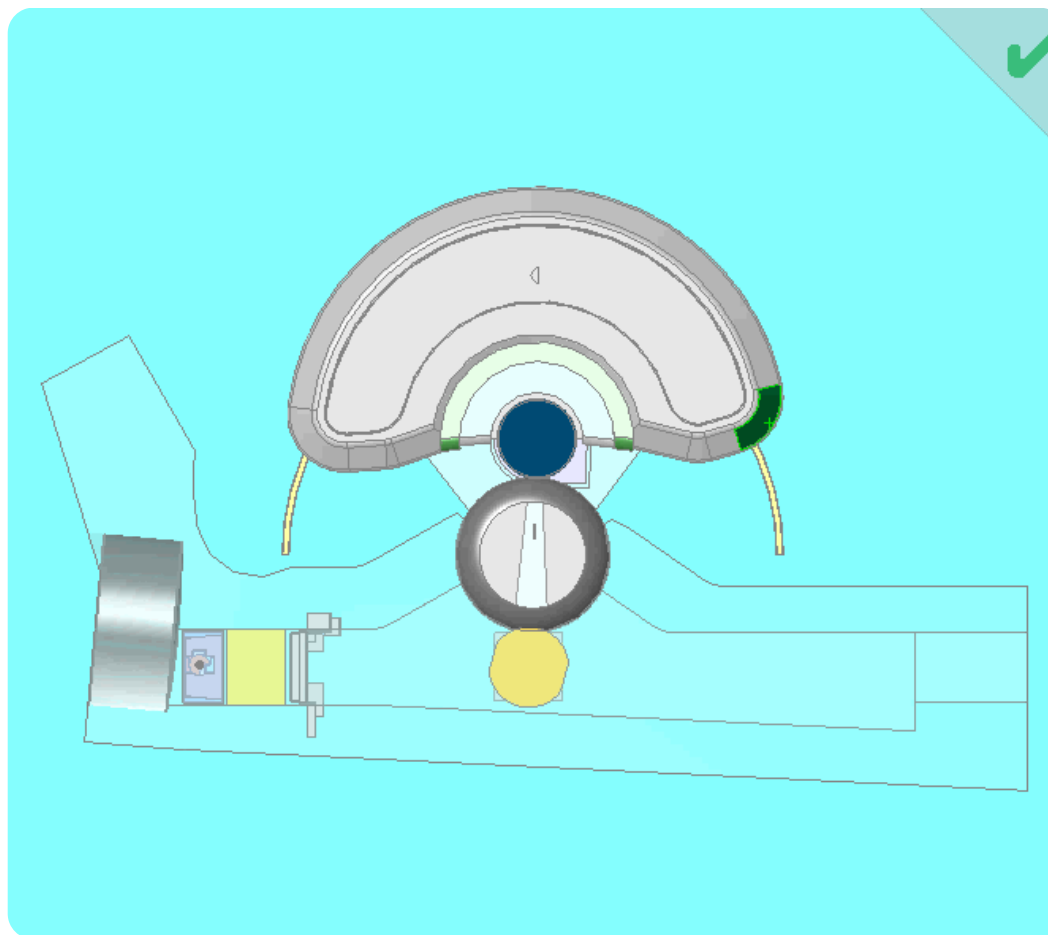
Perspective





Detector System Motion Control

Plan View

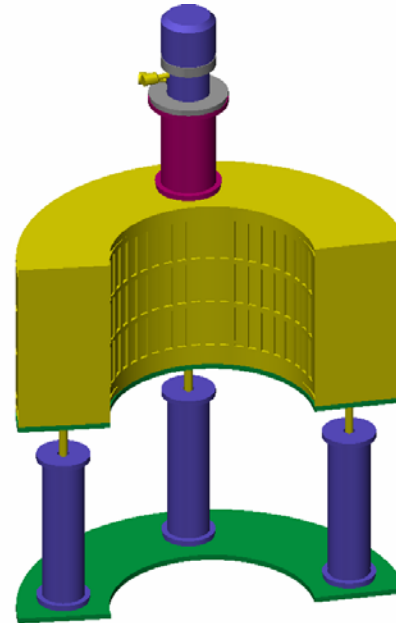
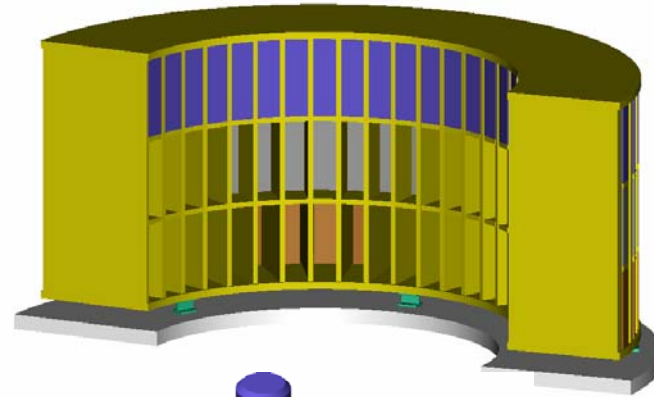
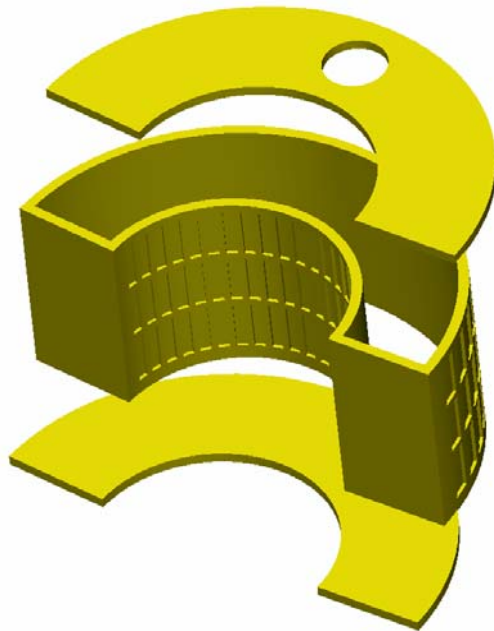




Post Sample Cryo Filter Exchanger

Perspective Views

Illustrations Courtesy of JHU IDG





Double Crystal Analyzer Linkage

- Engineering Challenges

Precision Mechanism with 2 Theta Output

- Design Approach

Adaptation of Golovchenko Mechanism

- Optimization

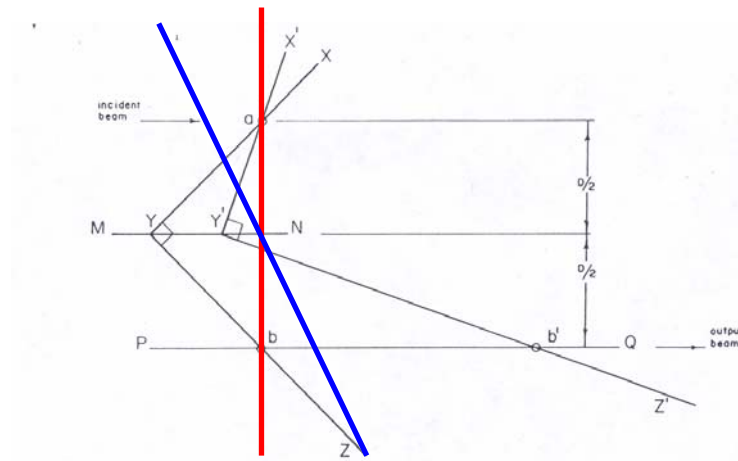
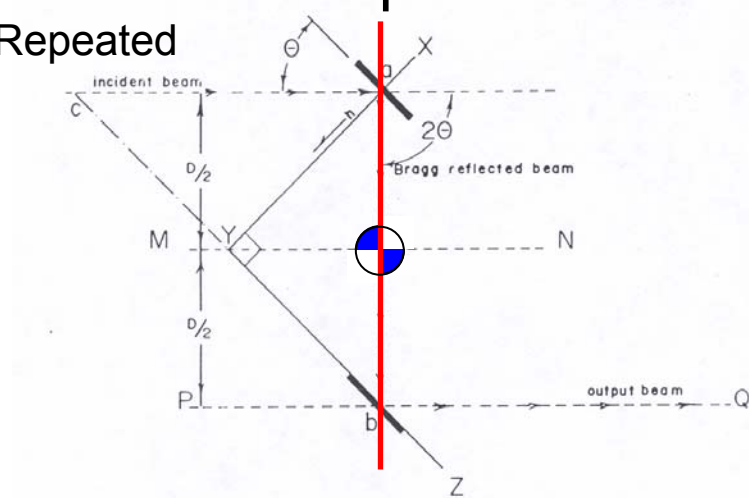
Shielding, Tolerances

- What's Next?

Life testing, Accuracy Testing, Neutron Beam Testing

Monochromator Concept Basis

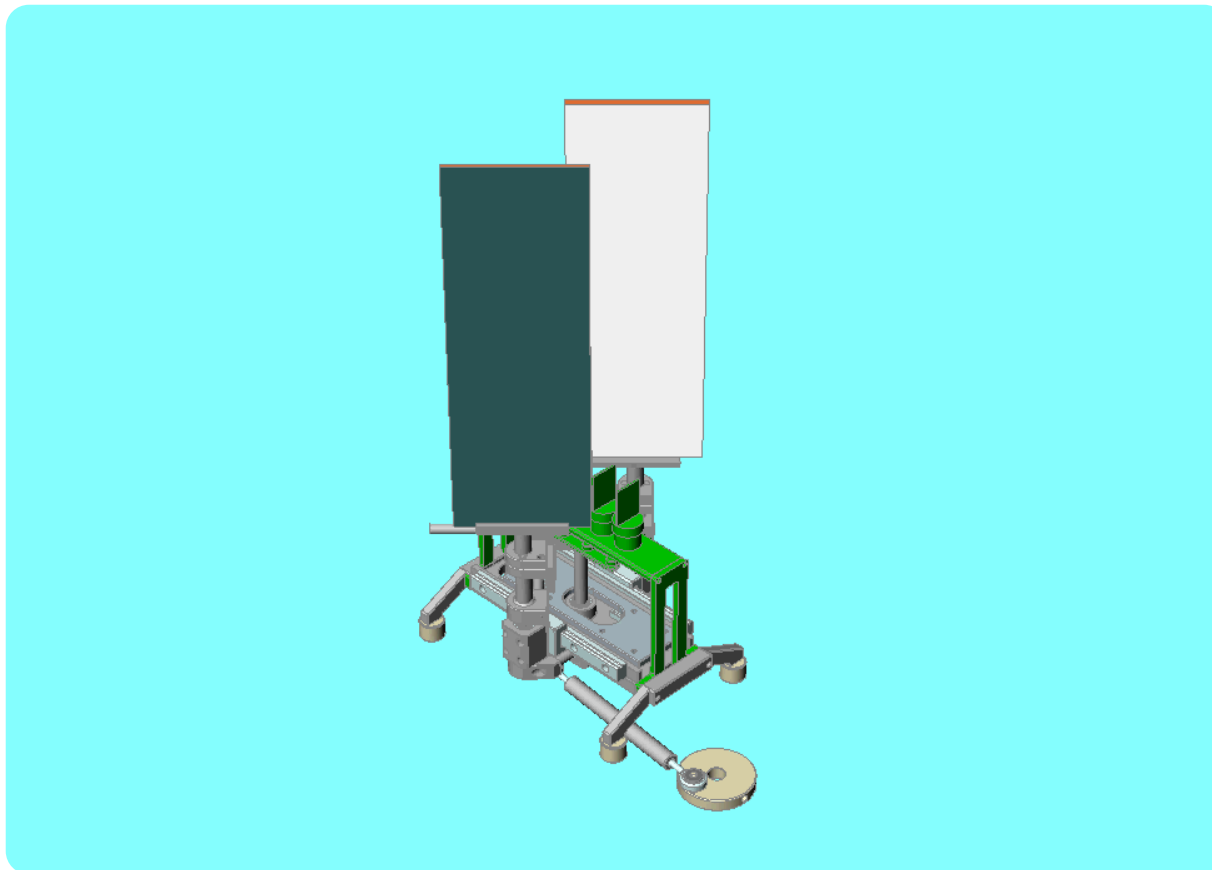
Figures 1 & 2 Repeated





Double Crystal Analyzer Linkage

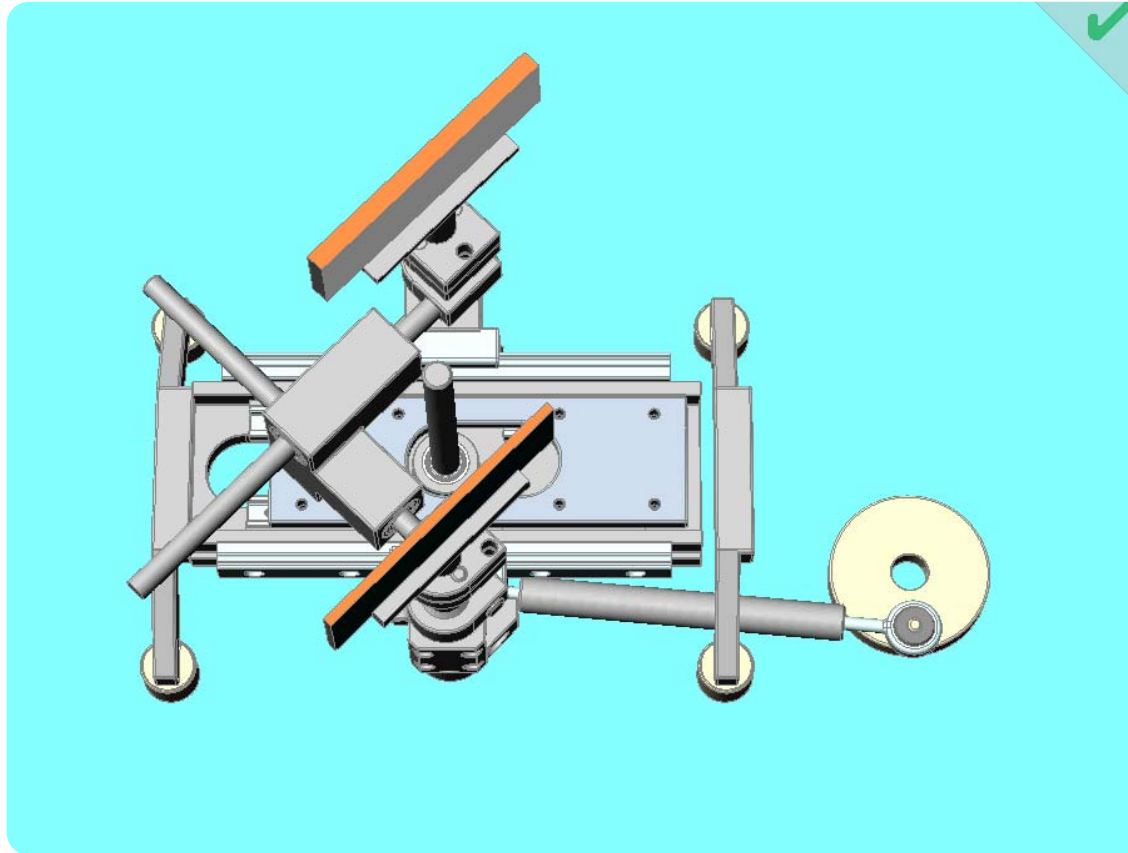
Prototype Perspective 1





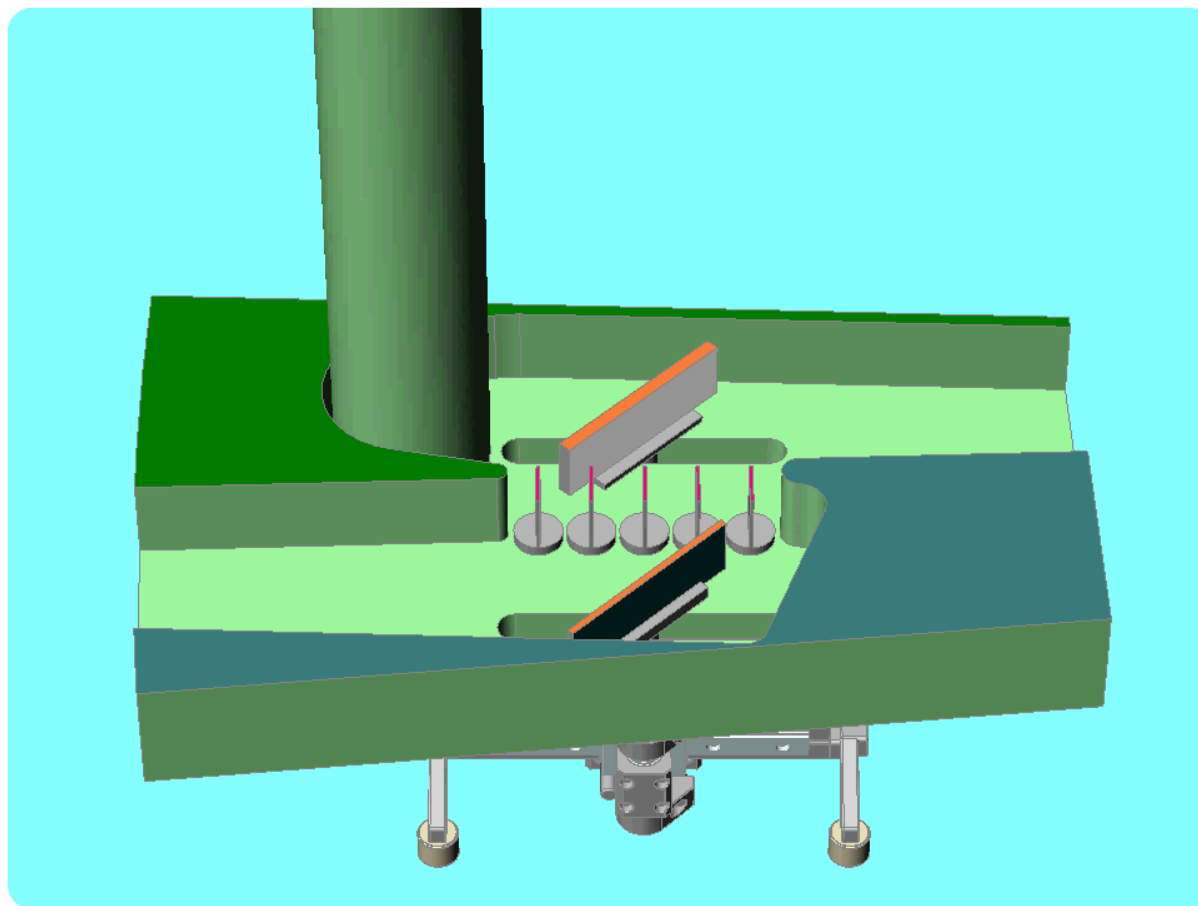
Double Crystal Analyzer Linkage

Prototype Perspective 2



Double Crystal Analyzer Linkage

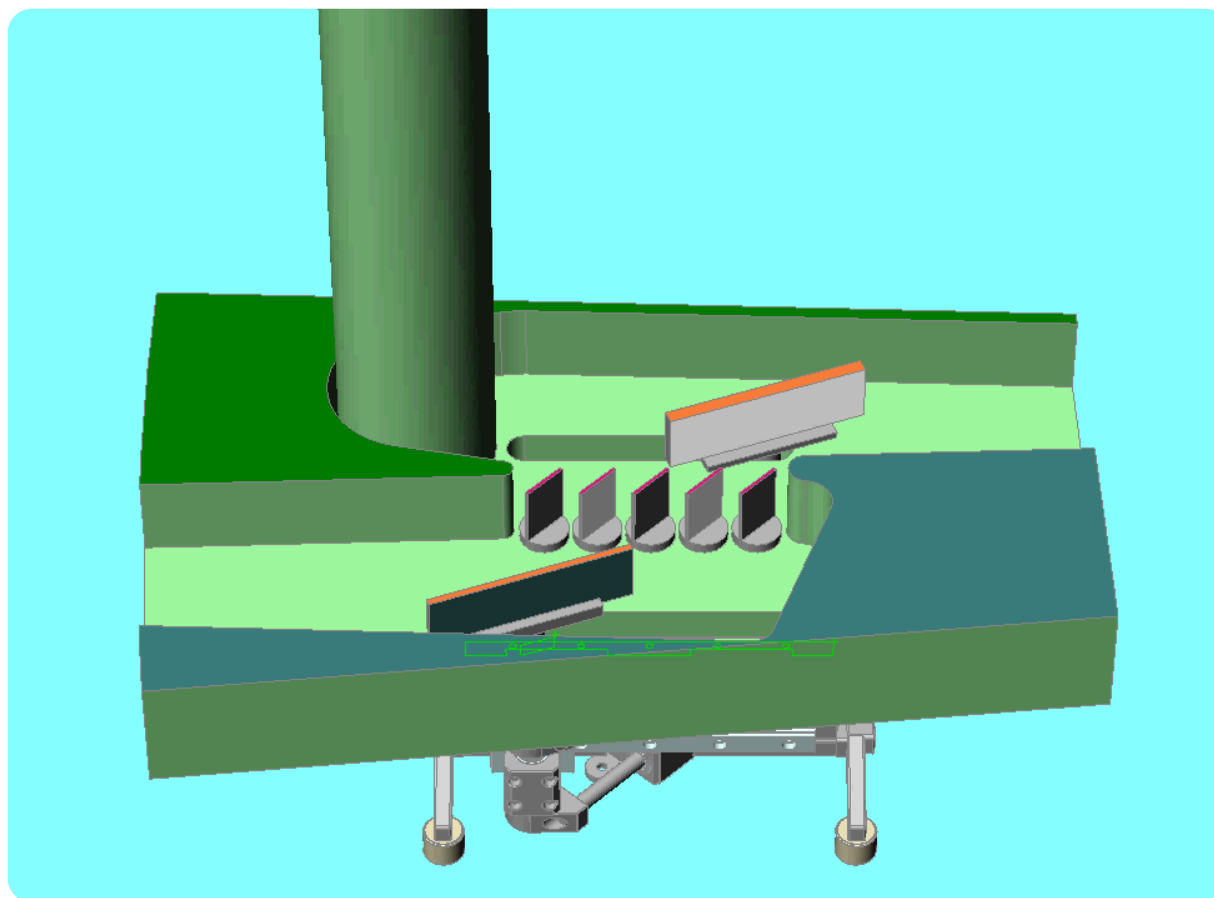
Prototype Perspective 3





Double Crystal Analyzer Linkage

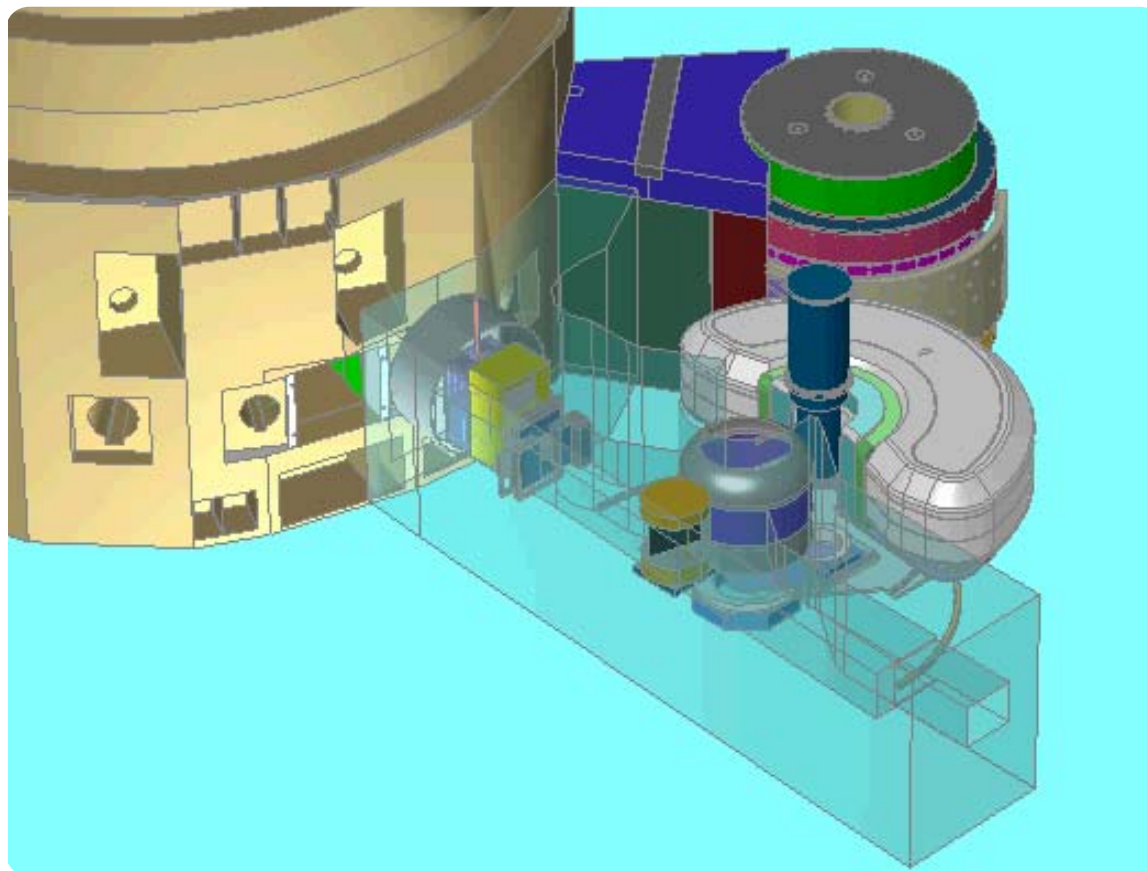
Prototype Perspective 4





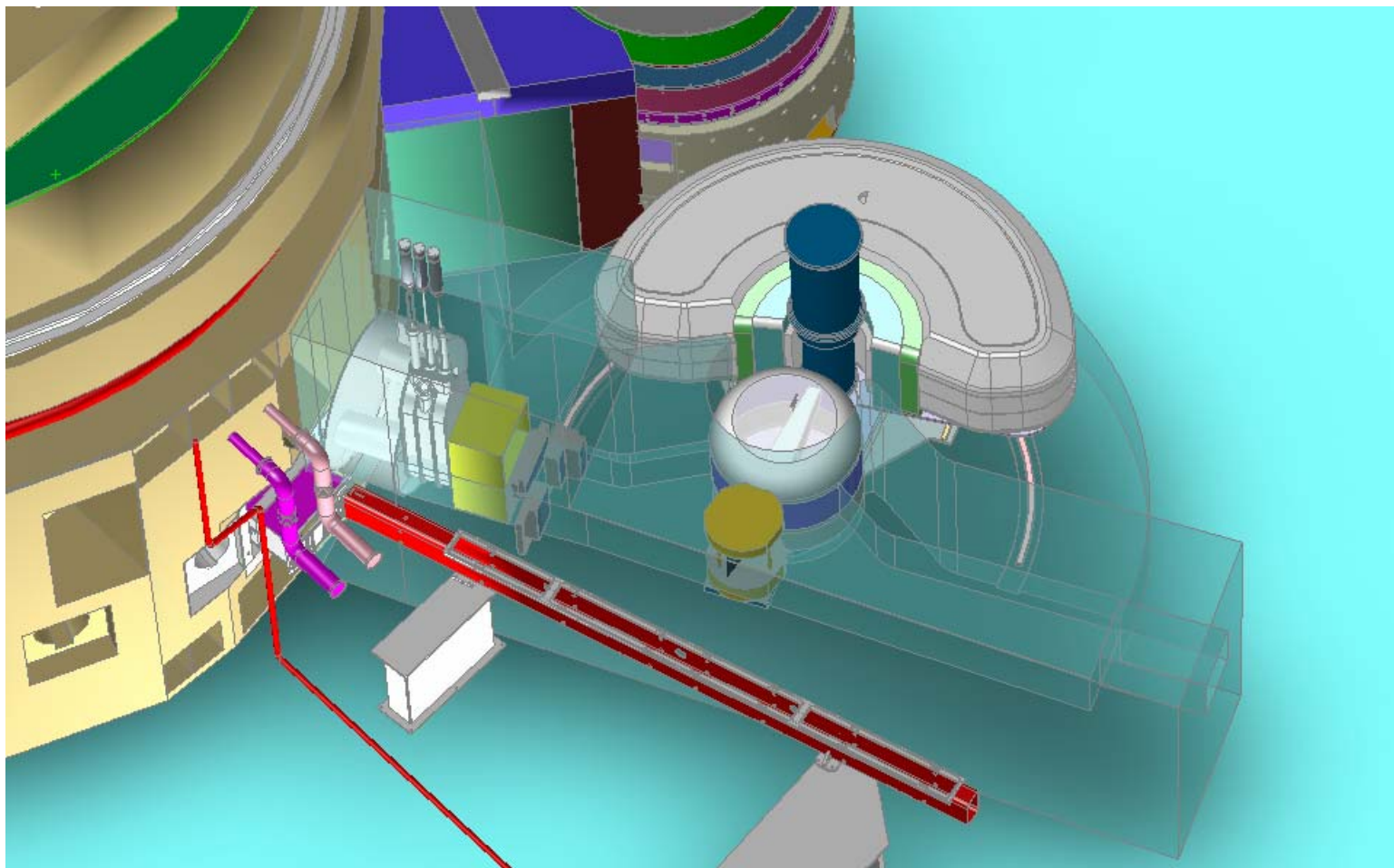
MACS General Layout

C-100 Perspective 2



MACS General Layout

C-100 Perspective 3





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NIST Center for Neutron Research
NIST Physics Laboratory
Advanced Light Source, LBNL

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MACS

JUNE 2005

At a Beamline Near YOU

